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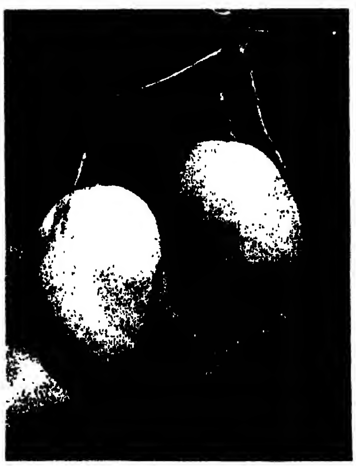

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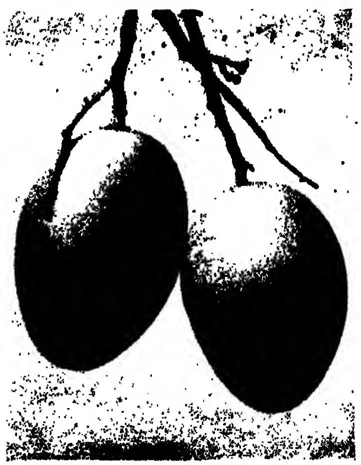

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MANGIFERA INDICA — FRUITS OF IMPORTANT COMMERCIAL TYPES

1. Mulgoa 2. Safdar Pasand 3. Neelum 4. Suvarnarekha 5. Bangalora 6. Alphonso 7. Samar Behisht Chawsa 8. Dusehri 9. Langra

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INTRODUCTION

This volume, the sixth in the series, contains 388 entries—367 on plant species, 11 on animals and animal products, and 10 on minerals. It is bigger than any of the previous volumes and it includes some articles the compilation of which has presented some particular difficulties. Published information on some of the topics dealt with is scarce, that on some others is extensive but confused; in some cases literature surveys have cast doubts on the accuracy of published information and for obtaining clarification, specialists had to be consulted and authentic material from the field or from trade sources had to be obtained for examination. Particular mention may be made, in this connection, of articles on *Luvunga*, *Madhuca*, *Malus*, *Mentha* and *Musa*. Every effort has been made, as in the previous volume, to present information after proper appraisal.

The following contributions from external sources (names given within brackets) have been utilized in preparing the articles: *Lac & Lac Insect* (Lac Research Institute, Ranchi & Dr. A. P. Kapur, Zoological Survey of India, Calcutta); *Leeches* (Dr. M. L. Bhatia, Delhi); *Lignite* (Dr. M. S. Iyengar, Shri T. N. Basu & Dr. A. Lahiri, Central Fuel Research Institute, Jealgora); *Limestone* (Prof. C. Mahadevan, Andhra University, Waltair); *Linum* (Dr. Richharia, Cuttack & Shri R. N. Chaturvedi, Marketing Directorate, Nagpur); *Lion* (Shri P. D. Stracey, Dehra Dun); *Locusts* (Dr. K. B. Lal, Plant Protection Adviser, New Delhi); *Madhuca* (Dr. Ichaporia, Tata Oil Mills, Bombay); *Manganese Ores* (Dr. Daya Swarup & Shri V. G. Iyer, Banaras Hindu University, Banaras); *Magnesite* (Shri H. R. Robinson, Magnesite Syndicate Ltd., Salem); *Mangifera* (Shri S. R. Gandhi, Poona); *Malus*, *Manihot*, *Mangifera* and *Musa* (Central Food Technological Research Institute, Mysore); *Mineral springs* (Dr. P. K. Ghosh, Dept. of Atomic Energy, New Delhi); and *Monazite* (Shri A. Venkatachalam Iyer, University College, Trivandrum). Many articles have been scrutinized by specialists and information has been received from a large number of sources. To all contributors, referees and others, the Chief Editor is greatly indebted. He is grateful to Prof. A. F. Hill (Botanical Museum, Harvard Univ., U.S.A.), late Dr. D. Chatterjee (Indian Botanic Garden, Calcutta), Dr. S. K. Mukerjee (Central National Herbarium, Bot. Surv. India, Calcutta) and Shri M. B. Raizada (Forest Research Institute, Dehra Dun) for their advice on plant nomenclature, and to the President, Forest Research Institute, Dehra Dun, the Director, Indian Agricultural Research Institute, New Delhi, the Chief Botanist, Botanical Survey of India and the Superintendent, Lál Bagh Botanic Gardens, Bangalore, for the supply of illustrations.

The Chief Editor desires to express his gratitude to Prof. M. S. Thacker in particular and to each of the other members of the Editorial Committee for help, guidance and criticism. He is especially indebted to Rev. H. Santapau for assistance in the compilation of botanical articles and to Dr. Baini Prashad for guidance and supervision of the work of the Zoological Unit located at Dehra Dun. He also wishes to place on record his grateful appreciation of the unstinted labour and loyal co-operation of his colleagues and staff.

The Chief Editor is keenly conscious of the need for completing the compilation of the remaining volumes expeditiously. The nature of the undertaking, involving as it does an exhaustive scrutiny of the continuously growing scientific literature, critical appraisal of data collected from diverse sources and refereeing of completed articles by specialists, sets limits to the speeding up of the compilation. It is realised that the information contained in the earlier volumes is getting out of date and at the instance of the Publications Committee, revision of these volumes is being concurrently taken on hand.

Suggestions for improvement will be received and made use of in subsequent volumes.

New Delhi

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PLATES

TEXT FIGURES

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Barry	Natural Varnish Resins, by T. H. Barry (Ernest Benn Ltd., London), 1932.
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Acta chem. scand.	Acta chemical scandinavia. Kobenhavn.
Acta phytother., Amst.	Acta Phytotherapeutica. Amsterdam.
Adm. Rep., Dep. Agric. Mysore	Administrative Report. Department of Agriculture. Mysore.
Agra Univ. J. Res. (Sci.)	Agra University Journal of Research. Agra. (Science)
Agric. Anim. Husb., Uttar Pradesh	Agriculture and Animal Husbandry. Uttar Pradesh. Lucknow.
Agric. Handb. U.S. Dep. Agric.	Agriculture Handbook. United States Department of Agriculture. Washington, D.C.
Agric. Inform. Bull. U.S. Dep. Agric.	Agriculture Information Bulletin. U.S. Department of Agriculture. Washington, D.C.
Agric. J. India	Agricultural Journal of India. Pusa.
Agric. Ledger	Agricultural Ledger. Calcutta.
Agric. Live-Stk India	Agriculture and Live-Stock in India. New Delhi.
Agric. Newslett., Aust.	Agricultural Newsletter. Australian Government Trade Information Service. Bombay.
Agric. Situat. India	Agricultural Situation in India. New Delhi.
Agriculture, Lond.	Agriculture. London.
Agron. J.	Agronomy Journal. Washington, D.C.
Allahabad Fmr	Allahabad Farmer. Allahabad.
Allg. Oel u. Fettztg	Allgemeine Oel-und Fettzeitung. Berlin.
Amer. J. Bot.	American Journal of Botany. Lancaster, Pa.
Amer. J. Pharm.	American Journal of Pharmacy. Philadelphia.
Andhra agric. J.	Andhra Agricultural Journal. Bapatla, Andhra.
Ann. Biochem.	Annals of Biochemistry and Experimental Medicine. Calcutta.
Ann. Bot., Lond.	Annals of Botany. London.
Ann. R. bot. Gdn Calcutta	Annals of the Royal Botanic Garden, Calcutta.
Annu. Rep., Dep. Atomic Energy	Annual Report. Department of Atomic Energy. New Delhi.
Annu. Rep. Indian Coun. agric. Res.	Annual Report of the Indian Council of Agricultural Research. New Delhi.
Annu. Rep. Indian Lac Res. Inst.	Annual Report. Indian Lac Research Institute. Namkum.
Annu. Rep. Indian Oilseeds Comm.	Annual Report of the Indian Central Oilseeds Committee. Hyderabad.
Annu. Rep. Indian vet. Res. Inst.	Annual Report of the Indian Veterinary Research Institute. Mukteswar and Izatnagar.
Annu. Rep. Mysore geol. Dep.	Annual Report of the Mysore Geological Department. Bangalore.
Annu. Rep. Res. Dep. Coffee Bd India	Annual Report. Research Department, Coffee Board, India. Bangalore.
Annu. Rev. biochem. Res. India	Annual Review of the Biochemical and Allied Research in India. Bangalore.
Anti Locust Bull.	Anti-Locust Bulletin. London.
Antiseptic	Antiseptic. Madras.
Araneta J. Agric.	Araneta Journal of Agriculture. Philippines.
Arch. Biochem.	Archives of Biochemistry. New York.
Arch. Pharm., Berl.	Archiv der Pharmazie. Berlin.
Arecan. Bull.	Arecanut Bulletin. Kozhikode, Malabar.
Aust. J. agric. Res.	Australian Journal of Agricultural Research. Melbourne.
Aust. J. biol. Sci.	Australian Journal of Biological Sciences. Victoria. Australia.
Aust. J. Chem.	Australian Journal of Chemistry. Melbourne.
Aust. J. Sci.	Australian Journal of Science. Sydney.
Aust. J. sci. Res.	Australian Journal of Scientific Research. Melbourne.
Baileya	Baileya. Ithaca, New York.
Biochem. J.	Biochemical Journal. Cambridge.
Biochim. biophys. Acta	Biochimica et biophysica Acta. New York and Amsterdam.
Biol. Abstr.	Biological Abstracts. Philadelphia, Pa.
Blumea	Blumea. Holland.
Bot. Bull. Acad. sinica	Botanical Bulletin of Academia Sinica. Shanghai.
Bot. Gaz.	Botanical Gazette. Chicago.
Bot. Rev.	Botanical Review. Lancaster, Pa.
Brit. chem. Abstr.	British Chemical Abstracts. London.
Brit. J. Nutr.	British Journal of Nutrition. Cambridge.
Bull. Agric. Dep. Madhya Pradesh	Bulletin. Agricultural Department, Madhya Pradesh.
Bull. agric. Res. Inst. Pusa	Bulletin. Agricultural Research Institute, Pusa. Calcutta.
Bull. appl. Bot. Pl.-Breed.	Bulletin of Applied Botany and Plant Breeding. Leningrad.
Bull. bot. Soc. Beng.	Bulletin of the Botanical Society of Bengal. Calcutta.

Bull. Bur. Agric. Philipp.	Bulletin. Bureau of Agriculture, Philippine Islands. Manila.
Bull. Calcutta Sch. trop. Med.	Bulletin of the Calcutta School of Tropical Medicine. Calcutta.
Bull. cent. electrochem. Res. Inst.	Bulletin of the Central Electrochemical Research Institute. Karaikudi.
Bull. cent. Fd technol. Res. Inst., Mysore	Bulletin. Central Food and Technological Research Institute. Mysore.
Bull. cent. Leath. Res. Inst., Madras	Bulletin of the Central Leather Research Institute. Madras.
Bull. cent. Res. Inst. Univ. Travancore	Bulletin of the Central Research Institute, University of Travancore. Trivandrum.
Bull. cent. Silk Bd, India	Bulletin. Central Silk Board. India. Bombay.
Bull. Coun. sci. industr. Res. Aust.	Bulletin. Council for Scientific and Industrial Research, Australia. Melbourne.
Bull. Dep. Agric. Assam	Bulletin. Department of Agriculture, Assam. Shillong.
Bull. Dep. Agric. Bombay	Bulletin. Department of Agriculture, Bombay. Bombay.
Bull. Dep. Agric. Ceylon	Bulletin of the Department of Agriculture, Ceylon. Colombo.
Bull. Dep Agric. C.P.	Bulletin. Department of Agriculture, Central Provinces and Berar. Nagpur.
Bull. Dep Agric. Madras	Bulletin. Department of Agriculture, Madras. Madras.
Bull. Dep. Agric., U.P.	Bulletin of the Department of Agriculture. United Provinces. Allahabad.
Bull. Dep. Fish., Madras	Bulletin. Fisheries Department. Madras.
Bull. Dep. Ind. Beng.	Bulletin. Industries Department, Government of Bengal. Calcutta.
Bull. Dep. Ind. Comm. Unit. Prov., N.S.	Bulletin. Department of Industries and Commerce, United Provinces of Agra and Oudh. New Series. Allahabad.
Bull. Dep. Ind. Travancore	Bulletin. Department of Industries, Government of Travancore. Trivandrum.
Bull. Dep. Ind., U.P., N.S.	Bulletin. Department of Industries. United Provinces. New Series.
Bull. Dep. sci. industr. Res. N.Z.	Bulletin, Department of Scientific and Industrial Research, Wellington, New Zealand.
Bull. econ. Indoch.	Bulletin economique de l'Indochine. Hanoi.
Bull. ent. Res.	Bulletin of Entomological Research. London.
Bull. Fd Sci. Ext. Serv.	Bulletin. Food Science Extension Service. Mysore.
Bull. Fla agric. Exp. Sta.	Bulletin. Florida Agricultural Experiment Station. Gainesville.
Bull. geol. Surv. India	Bulletin of the Geological Survey of India. Calcutta.
Bull. Hawaii agric. Exp. Sta.	Bulletin. Hawaii Agricultural Experiment Station. Honolulu.
Bull. Hyderabad geol. Ser.	Bulletin. Hyderabad Geological Series. Hyderabad-Deccan.
Bull. imp. Inst., Lond.	Bulletin of the Imperial Institute. London.
Bull. Indian Cocon. Comm.	Bulletin Issued by the Indian Central Coconut Committee. Kozhikode.
Bull. Indian Coun. agric. Res.	Bulletin. Indian Council of Agricultural Research. New Delhi.
Bull. Indian Lac Res. Inst.	Bulletin of the Indian Lac Research Institute. Namkum.
Bull. Lloyd Libr., Reprod. Ser.	Bulletin of the Lloyd Library of Botany, Pharmacy and Materia Medica. Reproduction Series. Cincinnati.
Bull. Madras Govt. Mus., N.S.	Bulletin of the Madras Government Museum. New Series. Madras.
Bull. Minist. Agric., Lond.	Bulletin. Ministry of Agriculture and Fisheries. London.
Bull. nat. bot. Gdns, Lucknow	Bulletin. National Botanic Gardens. Lucknow.
Bull. nat. Inst. Sci. India	Bulletin of the National Institute of Sciences of India. New Delhi.
Bull. Org. sci. Res. Indonesia	Bulletin of the Organization for Scientific Research in Indonesia. Djakarta.
Bull. Pharmacogn. Lab.	Bulletin. Pharmacognosy Laboratory. Ministry of Health, Govt. of India. New Delhi.
Bull. Res. Inst., Univ. Kerala	Bulletin of the Central Research Institute. University of Kerala. Trivandrum.
Bull. Res. Inst., Univ. Travancore	Bulletin of the Central Research Institute. University of Travancore. Trivandrum.
Bull. sci. industr. Res. Org. Aust.	Bulletin. Commonwealth Scientific and Industrial Research Organization, Australia. Melbourne.
Bull. Sci. pharm.	Bulletin des sciences pharmacologiques. Paris.
Bull. Uttar Pradesh For. Dep.	Bulletin. Uttar Pradesh Forest Department. Allahabad.
Canad. J. agric. Sci.	Canadian Journal of Agricultural Science (Formerly Scientific Agriculture). Ottawa.
Canad. J. Bot.	Canadian Journal of Botany. Ottawa.
Canad. J. Chem.	Canadian Journal of Chemistry. Ottawa.
Canad. J. Res.	Canadian Journal of Research. Ottawa.
Candollea	Candollea. Geneve.
Census of Indian Manufactures	Census of Indian Manufactures. Calcutta.
Chem. Abstr.	Chemical Abstracts. Easton, Pa.
Chem. Age India	Chemical Age of India. Bombay.
Chem. & Ind.	Chemistry and Industry. London.
Chem. Engng News	Chemical and Engineering News. Easton, Pa.
Chemurg. Dig.	Chemurgic Digest. Columbus, Ohio.
Circ. Kans. agric. Coll. Exp. Sta.	Circular. Kansas Agricultural College Experiment Station. Manhatten.
Circ. Univ. Fla agric. Exp. Sta.	Circular. University of Florida Agricultural Experiment Station. Gainesville.
Circ. U.S. Dep. Agric.	Circular. United States Department of Agriculture. Washington.
Cocon. Bull.	Coconut Bulletin. Ernakulam.

Colon. Pl. Anim. Prod.	Colonial Plant and Animal Products. London.
CSIR News	CSIR News. New Delhi.
Curr. Sci.	Current Science. Bangalore.
Cytologia, Tokyo	Cytologia. Tokyo.
E. Afr. agric. J.	East African Agricultural Journal. Nairobi.
East. Met. Rev.	Eastern Metals Review. Calcutta.
East. Pharm.	Eastern Pharmacist. New De'hi.
Econ. Bot.	Economic Botany. Lancaster, Pa.
Emp. J. exp. Agric.	Empire Journal of Experimental Agriculture. Oxford.
Euphytica	Euphytica Netherlands Journal of Plant Breeding. Wageningen (Netherlands).
FAO nutr. Stud.	FAO Nutritional Studies. Rome.
Farm Bull., Indian Coun. agric. Res.	Farm Bulletin. Indian Council of Agricultural Research. New Delhi.
Farm News Release, Indian Coun. agric Res.	Farm News Release. Indian Council of Agricultural Research. New Delhi.
Farmer	Farmer. Bombay.
Fertiliser News	Fertiliser News. New Delhi.
Field Crop Abstr.	Field Crop Abstracts. Aberystwyth.
Fieldiana, Bot.	Fieldiana: Botany. Chicago.
Fmg in S. Afr.	Farming in South Africa. Pretoria.
Fmrs' Bull., U.S. Dep. Agric.	Farmers' Bulletin. United States Department of Agriculture. Washington, D.C
Food Ind.	Food Industries. New York.
Food Manuf.	Food Manufacture. London.
Food Res.	Food Research. Champaign, Ill
Food Sci.	Food Science. Mysore.
Food Sci. Abstr.	Food Science Abstracts. London
Food Technol., Champaign	Food Technology. Champaign.
Foreign Agric.	Foreign Agriculture. Washington, D.C.
For. Bull., Econ. Ser.	Forest Bulletin. Economy Series. Delhi.
For. Res. India	Forest Research in India (and Burma). Calcutta.
Fruit Prod. J.	Fruit Products Journal and American Food Manufacturer. New York.
Gardening	Gardening. Lucknow.
Gdn J., N.Y.	Garden Journal of the New York Botanical Garden. New York.
Gdns' Bull.	Gardens' Bulletin. Straits Settlements. Singapore.
Handb. Inst. Nutr. Philipp.	Handbook. Institute of Nutrition, Philippines. Manila.
Hlth Bull.	Health Bulletin. New Delhi.
Hort. Abstr.	Horticultural Abstracts. East Malling.
Hort. Adv.	Horticultural Advance. Saharanpur.
Ind Com J.	Ind Com Journal. Madras.
Indian Bee J.	Indian Bee Journal. Naini Tal, Uttar Pradesh.
Indian Ceram.	Indian Ceramics. Calcutta.
Indian Constr. News	Indian Construction News. Calcutta.
Indian east. Engr	Indian and Eastern Engineer. Calcutta.
Indian Fd Packer	Indian Food Packer. Bombay.
Indian Fmg	Indian Farming. New Delhi.
Indian Fmg, N.S.	Indian Farming. New Series. New Delhi.
Indian For.	Indian Forester. Dehra Dun.
Indian For. Bull.	Indian Forest Bulletin. Dehra Dun.
Indian For. Bull., N.S.	Indian Forest Bulletin. New Series. Dehra Dun.
Indian For. Leafl.	Indian Forest Leaflets. Dehra Dun.
Indian For. Rec.	Indian Forest Records. Dehra Dun.
Indian For. Rec N.S., Bot.	Indian Forest Records. New Series. Botany. Dehra Dun.
Indian For. Rec, N.S., Chem.	Indian Forest Records. New Series. Chemistry. Dehra Dun.
Indian For. Rec. N.S., Chem. & Minor For. Prod.	Indian Forest Records. New Series. Chemistry and Minor Forest Products. Dehra Dun.
Indian For. Rec, N.S., Ent.	Indian Forest Records. New Series. Entomology. Dehra Dun.
Indian For. Rec, N.S., Mycol.	Indian Forest Records. New Series. Mycology. Dehra Dun.
Indian For. Rec N.S., Timb. Mech.	Indian Forest Records. New Series. Timber Mechanics. Dehra Dun.
Indian For. Rec. N.S., Util.	Indian Forest Records. New Series. Utilisation. Dehra Dun.
Indian Hort.	Indian Horticulture. New Delhi.
Indian hort. Abstr.	Indian Horticultural Abstracts. New Delhi.
Indian J. agric. Sci.	Indian Journal of Agricultural Science. New Delhi.
Indian J. appl. Chem.	Indian Journal of Applied Chemistry. Calcutta.

Indian J. Dairy Sci.	Indian Journal of Dairy Science. Bangalore.
Indian J. Ent.	Indian Journal of Entomology. New Delhi.
Indian J. Genet.	Indian Journal of Genetics and Plant Breeding. New Delhi.
Indian J. Hort.	Indian Journal of Horticulture. New Delhi.
Indian J. med. Res.	Indian Journal of Medical Research. Calcutta.
Indian J. Pharm.	Indian Journal of Pharmacy. Bombay.
Indian J. Physiol.	Indian Journal of Physiology and Allied Sciences. Calcutta.
Indian J. vet. Sci.	Indian Journal of Veterinary Science and Animal Husbandry. New Delhi.
Indian med. Gaz.	Indian Medical Gazette. Calcutta.
Indian Miner.	Indian Minerals. Calcutta.
Indian Min. J.	Indian Mining Journal. Calcutta.
Indian Mus. Notes	Indian Museum Notes. Calcutta.
Indian Oilseeds J.	Indian Oilseeds Journal. Hyderabad.
Indian Oil & Soap J.	Indian Oil and Soap Journal. Calcutta.
Indian Perfum.	Indian Perfumer. Kanpur.
Indian Pharm.	Indian Pharmacist. Calcutta.
Indian Phytopath.	Indian Phytopathology. New Delhi.
Indian Pulp Pap.	Indian Pulp and Paper. Calcutta.
Indian Soap J.	Indian Soap Journal. Calcutta.
Indian Text. J.	Indian Textile Journal. Bombay.
Indian Tr. J.	Indian Trade Journal. Calcutta.
Indian zool. Mem.	Indian Zoological Memoirs. Lucknow.
Industr. Engng Chem.	Industrial and Engineering Chemistry. Easton, Pa.
Industr. India	Industrial India. Bombay.
Industry, Calcutta	Industry. Calcutta.
Iron & Steel Rev.	Iron and Steel Review. Calcutta.
J. agric. chem. Soc. Japan	Journal of the Agricultural Chemical Society of Japan. Tokyo.
J. agric. Fd Chem.	Journal of Agricultural and Food Chemistry. Easton, Pa.
J. agric. Res.	Journal of Agricultural Research. Washington, D.C.
J. agric. Sci.	Journal of Agricultural Science. Cambridge.
J. Amer. chem. Soc.	Journal of the American Chemical Society. Easton, Pa.
J. Amer. Oil Chem. Soc.	Journal of the American Oil Chemists' Society. Chicago.
J. Amer. pharm. Ass., sci. Edn	Journal of the American Pharmaceutical Association. Scientific Edition. Columbus.
J. Arnold Arbor.	Journal of the Arnold Arboretum. Lancaster, Pa.
J. Asiat. Soc. Beng., N.S.	Journal and Proceedings of the Asiatic Society of Bengal. New Series. Calcutta.
J. Asiat. Soc. Sci.	Journal of the Asiatic Society, Science. Calcutta.
J. biol. Chem.	Journal of Biological Chemistry. Baltimore, Md.
J. Bombay nat. Hist. Soc.	Journal of the Bombay Natural History Society. Bombay.
J. chem. Soc.	Journal of the Chemical Society. London.
J. Coun. sci. industr. Res. Aust.	Journal of the Council for Scientific and Industrial Research, Australia. Melbourne.
J. Dairy Sci.	Journal of Dairy Science. Baltimore, Lancaster, Pa.
J. econ. Ent.	Journal of Economic Entomology. Geneva, N.Y.
J. Gujarat Res. Soc.	Journal of the Gujarat Research Society. Bombay.
J. Indian Bot.	Journal of Indian Botany. Madras.
J. Indian bot. Soc.	Journal of the Indian Botanical Society. Madras.
J. Indian chem. Soc.	Journal of the Indian Chemical Society. Calcutta.
J. Indian chem. Soc., industr. Edn	Journal of the Indian Chemical Society. Industrial and News Edition. Calcutta.
J. Indian Inst. Sci.	Journal of the Indian Institute of Science. Bangalore.
J. Indian Rds Congr.	Journal of the Indian Roads Congress. New Delhi.
J. Instn Chem. India	Journal and Proceedings of the Institution of Chemists, India. Calcutta.
J. Leath. Technol. Ass. India	Journal of the Leather Technologists' Association (India). Calcutta.
J. Linn. Soc., Bot.	Journal of the Linnean Society. Botany. London.
J. Min. Metals & Fuels	Journal of Mines, Metals & Fuels. Calcutta.
J. Mysore agric. exp. Un.	Journal of the Mysore Agricultural and Experimental Union. Bangalore.
J. Mysore Univ.	Journal of the Mysore University. Mysore.
J. Nutr.	Journal of Nutrition. Philadelphia.
J. N. Y. bot. Gdn	Journal of the New York Botanical Garden. New York.
J. Oil Technol. Ass. India	Journal and Proceedings of the Oil Technologists' Association, India. Kanpur.
J. org. Chem.	Journal of Organic Chemistry. Easton, Pa.
J. Pharm., Lond.	Journal of Pharmacy and Pharmacology. London.
J. R. Asiat. Soc. Beng., Sci.	Journal of the Royal Asiatic Society of Bengal. Science. Calcutta.

J. R. Soc. N.S.W.	Journal and Proceedings of the Royal Society of New South Wales.
J. Sci. Ass., Vizianagram	Journal of the Science Association. Maharajah's College, Vizianagram. Madras.
J. Sci. Club, Calcutta	Journal of the Science Club. Calcutta.
J. Sci. Fd Agric.	Journal of the Science of Food and Agriculture. London.
J. sci. industr. Res.	Journal of Scientific and Industrial Research. New Delhi.
J. sci. Res. Banaras Hindu Univ.	Journal of Scientific Research of the Banaras Hindu University. Varanasi.
J. sci. Res. Indonesia	Journal for Scientific Research in Indonesia. Djakarta.
J. Soc. chem. Ind. Japan	Journal of the Society of Chemical Industry of Japan. Tokyo.
J. Soc. chem. Ind., Lond.	Journal of the Society of Chemical Industry. London.
J. Timb. Dryers' & Pres. Ass. India	Journal of the Timber Dryers' and Preservers' Association of India. Dehra Dun.
J. Univ. Baroda	Journal of University of Baroda. Baroda.
J. Univ. Bombay	Journal of the University of Bombay. Bombay.
J. Univ. Bombay, N.S.	Journal of the University of Bombay. New Series. Bombay.
J. Univ. Poona	Journal of the University of Poona, Science and Technology. Poona.
J. zool. Soc. India	Journal of the Zoological Society of India. Calcutta.
Jt Publ. imp. agric. Bur.	Joint Publications. Imperial (Commonwealth) Agricultural Bureau. Aberystwyth.
Jute Bull.	Jute Bulletin. Calcutta.
Kew Bull.	Kew Bulletin. Royal Botanic Gardens, Kew.
Kew Bull. Addl Ser.	Kew Bulletin. Additional Series. Royal Botanic Gardens, Kew.
Kulturpflanze	Die Kulturpflanze. Berlin.
Leafl. Dep. Agric. Bombay	Leaflet. Department of Agriculture, Bombay. Bombay.
Leafl. Dep. Agric. Ceylon	Leaflet. Department of Agriculture. Ceylon.
Leafl. Dep. Agric. Madras	Leaflet. Department of Agriculture, Madras. Madras.
Leafl. U.S. Dep. Agric.	Leaflet. United States Department of Agriculture. Washington, D.C.
Lloydia	Lloydia. Columbus, Ohio.
Lucknow Univ. Stud.	Lucknow University Studies. Lucknow.
Madras agric. J.	Madras Agricultural Journal. Coimbatore.
Malay. agric. J.	Malayan Agricultural Journal. Kuala Lumpur.
Mem. Dep. Agric. India, Bot.	Memoirs of the Department of Agriculture in India. Botanical Series. Pusa.
Mem. Dep. Agric. Madras	Memoirs of the Department of Agriculture, Madras. Madras.
Mem. geol. Surv. India	Memoirs of the Geological Survey of India. Calcutta.
Mem. Indian Mus.	Memoirs of the Indian Museum. Calcutta.
Mem. Tocklai exp. Sta.	Memoirs of the Tocklai Experimental Station. Assam.
Minerals Yearb., Wash.	Minerals Yearbook. Washington, D.C.
Misc. Bull., Indian Coun. agric. Res.	Miscellaneous Bulletin. Indian Council of Agricultural Research. New Delhi.
Misc. Bull. U.S. Dep. Agric.	Miscellaneous Bulletin. U.S. Department of Agriculture.
Misc. Publ. U.S. Dep. Agric.	Miscellaneous Publication. United States Department of Agriculture. Washington, D.C.
Mysore agric. J.	Mysore Agricultural Journal. Bangalore.
Nagpur agric. Coll. Mag.	Nagpur Agricultural College Magazine. Nagpur.
Nat. geogr. Mag.	National Geographic Magazine. Washington, D.C.
Nature, Lond.	Nature. London.
Naturwissenschaften	Naturwissenschaften. Berlin.
New Phytol.	New Phytology. Cambridge.
N.Z.J. Sci. Technol.	New Zealand Journal of Science and Technology. Wellington.
Nutr. Abstr. Rev.	Nutrition Abstracts and Reviews. Aberdeen.
Oil Fat Ind.	Oil and Fat Industries. New York.
Oils & Oilseeds J.	Oils & Oilseeds Journal. Bombay.
Oilseeds Ser., Indian Oilseeds Comm.	Oilseeds Series. Indian Central Oilseeds Committee. Hyderabad.
Pacif. Sci.	Pacific Science. Honolulu.
Paintindia	Paintindia. Bombay.
Pakist. J. For.	Pakistan Journal of Forestry. Abbottabad, Pakistan.
Pakist. J. Sci.	Pakistan Journal of Science. Lahore.
Pakist. J. sci. Res.	Pakistan Journal of Scientific Research. Lahore.
Palaeobotanist	Palaeobotanist. Lucknow.
Perfum. essent. Oil Rec.	Perfumery and Essential Oil Record. London.
Philipp. Agric.	Philippine Agriculturist. Los Banos.
Philipp. agric. Rev.	Philippine Agricultural Review. Manila.
Philipp. J. Agric.	Philippine Journal of Agriculture. Manila.
Philipp. J. Sci.	Philippine Journal of Science. Manila.
Phytopathology	Phytopathology. Lancaster, Pa.
Plant Breed. Abstr.	Plant Breeding Abstracts. Cambridge.

Plant Physiol.	Plant Physiology. Lancaster, Pa.
Poona agric. Coll. Mag.	Poona Agricultural College Magazine. Poona.
Proc. Amer. Soc. hort. Sci.	Proceedings. American Society for Horticultural Science. College Park, Md.
Proc. Bihar Acad. agric. Sci.	Proceedings of the Bihar Academy of Agricultural Science. Sabour, Bihar.
Proc. Indian Acad. Sci.	Proceedings of the Indian Academy of Sciences. Bangalore.
Proc. Indian Sci. Congr.	Proceedings of the Indian Science Congress. Calcutta.
Proc. nat. Acad. Sci. India	Proceedings of the National Academy of Sciences, India. Allahabad.
Proc. nat. Acad. Sci., Wash.	Proceedings of the National Academy of Sciences. Washington.
Proc. nat. Inst. Sci. India	Proceedings of the National Institute of Sciences of India. New Delhi.
Proc. Oil Technol. Ass. India	Proceedings of the Annual Convention of Oil Technologists' Association of India. Kanpur.
Punjab Fmr	Punjab Farmer. Simla.
Punjab Fr. J.	Punjab Fruit Journal. Lahore.
Qualit. Plant. Mat. Veg.	Qualitas Plantarum et Materiae Vegetabiles. The Hague.
Quart. J. Dep. Agric. Beng.	Quarterly Journal of the Department of Agriculture, Bengal. Calcutta.
Quart. J. geol. Soc. India	Quarterly Journal of the Geological, Mining and Metallurgical Society of India. Calcutta.
Rec. bot. Surv. India	Records of the Botanical Survey of India. Calcutta.
Rec. geol. Surv. India	Records of the Geological Survey of India. Calcutta.
Rec. Indian Mus.	Records of the Indian Museum. Delhi.
Rec. Mysore geol. Dep.	Records of the Mysore Geological Department. Bangalore.
Rep. agric. Exp. Sta. Univ. Hawaii	Report of the Agricultural Experiment Station, University of Hawaii. Honolulu.
Rep. agric. hort. Res. Sta., Bristol	Report of the Agricultural and Horticultural Research Station, University of Bristol, Long Ashton.
Rep. agric. Res. Inst. Pusa	Report of the Agricultural Research Institute and College, Pusa. Calcutta.
Rep. Dep. Agric. Travancore	Report. Department of Agriculture, Travancore. Trivandrum.
Rep. Dep. Nutr. Govt. Bombay	Report. Department of Nutrition, Govt. of Bombay. Bombay.
Rep. Dep. Res., Univ. Travancore	Report. Department of Research. University of Travancore. Trivandrum.
Rep. essent. Oils Schimmel	Annual Report on Essential Oils, Aromatic Chemicals and Related Materials. Schimmel & Co., New York.
Rep. Indian Oilseeds Comm.	Report. Indian Central Oilseeds Committee, Hyderabad.
Rep. Ohara Inst. agric. Res.	Report of the Ohara Institute of Agricultural Research. Okayama University.
Research	Research. London.
Res. & Ind.	Research & Industry. New Delhi.
Rev. Ser., Indian Coun. agric. Res.	Review Series. Indian Council of Agricultural Research. New Delhi.
Rev. Ver a Soie	Revue du ver a soie. France.
Sci. Abstr. China, biol. Sci.	Science Abstracts of China. Biological Sciences. Peking, China.
Science	Science. New York.
Sci. & Cult.	Science and Culture. Calcutta.
Sci. News Lett., Wash.	Science News Letter. Washington, D.C.
Sci. Progr.	Science Progress. Washington.
Sci. Rep. agric. Res. Inst. N. Delhi	Scientific Reports of the Indian (Imperial) Agricultural Research Institute, New Delhi.
Sci. Ser., Dep. Agric., Malaya	Scientific Series. Department of Agriculture. Federation of Malaya. Johore Bahru.
Silk Newslett.	Silk Newsletter. Bombay.
S. Indian Hort.	South Indian Horticulture. Coimbatore.
Soap Perfum. Cosm.	Soap Perfumery & Cosmetics. London.
Statist. Bull. Cott. Text. Ind., Bombay	Statistical Bulletin of Cotton Textile Industries. Bombay.
Statist. Summ. Miner. Ind.	Statistical Summary of the Mineral Industry, Overseas Geological Survey, London.
Statist. Yearb. United Nations	Statistical Yearbook, United Nations. New York.
Tech. Bull., Bur. agric. Inform. Uttar Pradesh, N.S.	Technical Bulletin, New Series. Bureaux of Agricultural Information, U.P. Lucknow.
Tech. Bull., U.S. Dep. Agric.	Technical Bulletin. U.S. Department of Agriculture. Washington, D.C.
Tech. Commun., imp. agric. Bur.	Technical Communication. Imperial (Commonwealth) Agricultural Bureau. Aberystwyth.
Tech. Rep. sci. adv. Bd, Indian Coun. med. Res.	Technical Report of the Scientific Advisory Board for the year 1951. Indian Council of Medical Research. New Delhi.
Telecommunications	Telecommunications. Jabalpur.
Tetrahedron Lett.	Tetrahedron Letter. London.
Tijdschr. PlZiekt.	Tijdschrift over Plantenziekten. Wageningen.
Tisco	Tisco. Technical Journal of the Tata Iron & Steel Company. Jamshedpur.
Tocklai exp. Sta. Memor.	Tocklai Experimental Station Memorandum. Assam.
Trans. Bose Res. Inst.	Transactions of the Bose Research Institute. Calcutta.

Trans. Indian ceram. Soc.	Transactions of the Indian Ceramic Society. Calcutta.
Trans. Indian Inst. Metals	Transactions of the Indian Institute of Metals. Calcutta.
Trans. Min. geol. Inst. India	Transactions of the Mining and Geological (and Metallurgical) Institute of India. Calcutta.
Trans. nat. Inst. Sci. India	Transactions of the National Institute of Sciences of India. Calcutta.
Trop. Abstr.	Tropical Abstracts. Amsterdam. Netherlands.
Trop Agriculture, Trin.	Tropical Agriculture. Trinidad.
Trop. Agriculturist	Tropical Agriculturist and Magazine of the Ceylon Agricultural Society. Peradeniya.
Trop. Sci.	Tropical Science. London.
Two & A Bud	Two and A Bud. Assam.
Univ. Tex. Publ.	University of Texas Publications. Austin.
Watsonia	Watsonia. London.
World Crops	World Crops. London.
Yearb. Agric., U.S. Dep. Agric.	Yearbook of Agriculture. United States Department of Agriculture. Washington, D.C.
Yearb. Dep. Agric. Madras	Yearbook. Department of Agriculture, Madras.
Zool. Anz.	Zoologischer Anzeiger. Leipzig.
Zuchter	Zuchter. Zeitschrift fur theoretische und angewandte Genetik. Berlin.

RAW MATERIALS

VOL. VI : L — M

L

Lablab Bean — *see* **Dolichos**

Laburnum, Indian — *see* **Cassia**

LAC AND LAC INSECT

D.E.P., II, 409; IV, 570; C.P., 1053.

Sans.– *Laksha*; Hindi—*Lakh*; Beng.—*Gala*; Guj. —*Lak*; Tel. -*Kommolakka*; Tam.—*Komburrki*; Mal.—*Arakku*, *ambalu*.

Lac is the resinous protective secretion of the tiny lac insect (Genus *Laccifer*, family *Lacciferidae*, order *Hemiptera*) which is a pest on a number of plants, both wild and cultivated. The minute red coloured larvae of the insect settle on young succulent shoots of the host plant in myriads, drive their long proboscis into the bark and draw their nutriment from the sap. They secrete a thick resinous fluid which envelopes their bodies; and the secretions from individual insects coalesce and form a hard continuous encrustation over the twigs. After the completion of the life cycle, and just about the time the larvae of the next generation begin to emerge, the twigs are harvested and the encrustations scraped off, dried and processed to yield the lac of commerce.

The resinous secretion of the lac insect and the red colouring matter obtainable therefrom, have been known in India since early times and used in art and manufactures. Interest in lac outside India dates back to the beginning of the nineteenth century, perhaps a little earlier, when lac dye began to attract attention as an alternative or adjunct to cochineal [from *Dactylopius coccus* (*Coccus cacti*)]. With the advent of aniline dyestuffs, however, the importance of lac dye declined, while that of the resin as a thermoplastic moulding material and as the basis of valuable varnishes and polishes gained recognition. Since then, lac has found application in diverse industries and has attained an important place in international trade and commerce. India held a virtual monopoly of lac and till about 1950, accounted for nearly 85% of the world's production of sticklac. Since 1950, however, lac production in Thailand has increased and it now supplies 25–30% of the world's requirements. India produces at present *c.* 1,100 thousand maunds of sticklac and exports *c.* Rs. 6.5 crores worth of shellac, seedlac, etc. every year (Sen, *Silver Jubilee Souvenir*, Indian Lac Cess Comm., 1931–56, 119).

Success in lac production is closely associated with the knowledge and application of the pest-host relationship, viz. the life cycle of the lac insect as related to the sylvicultural management of host plants, on which it thrives. During the past thirty years considerable advance has been made in the knowledge of this relationship, particularly as a result of investigations conducted at the Lac Research Institute at Namkum, Bihar.

Lac Insect

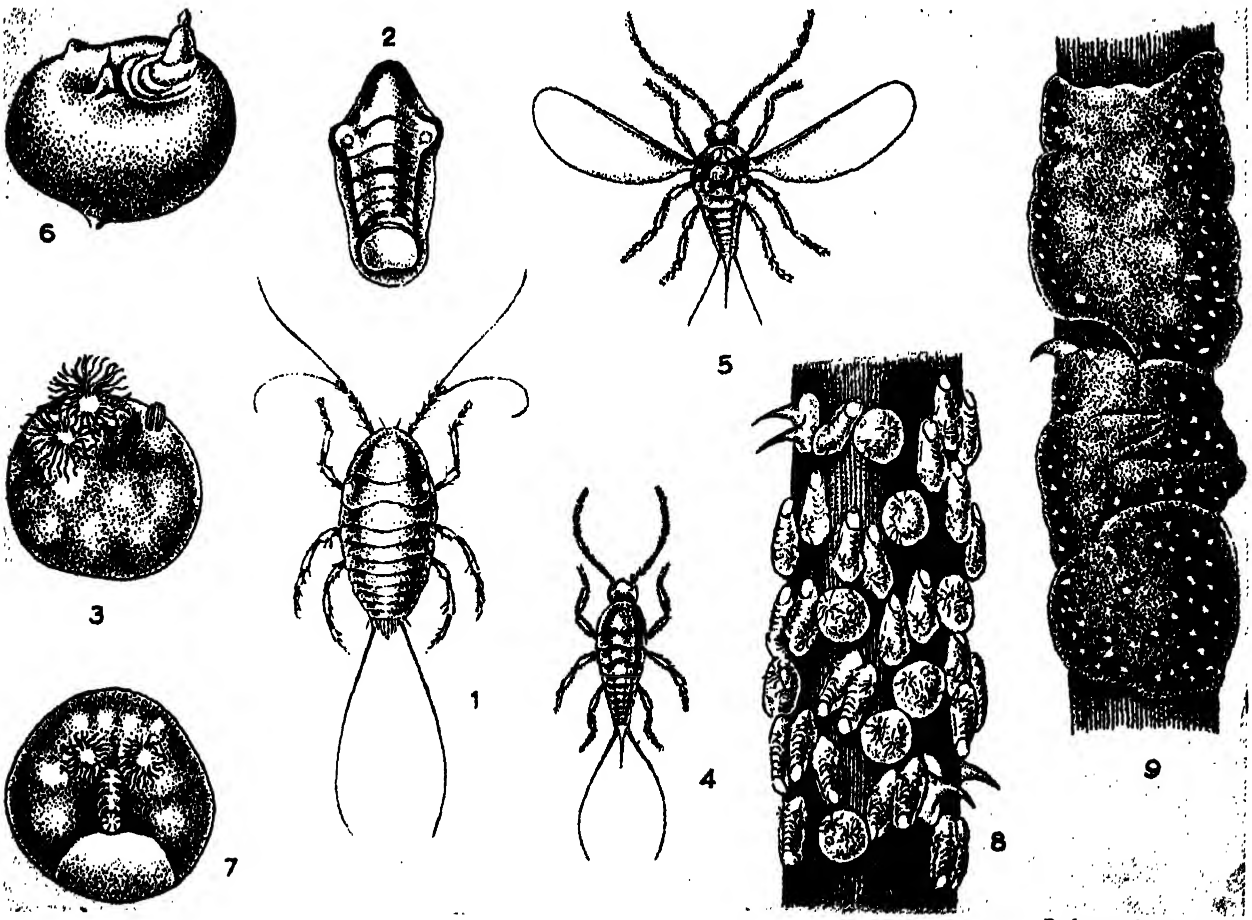
The commonest and the most widely occurring species of lac insect in India is *Laccifer lacca* (Kerr) which produces the bulk of commercial lac. Fourteen species of the genus have been recorded in India, but much confusion prevails regarding their exact identity, and it is possible that many of them are only strains or varieties of *Laccifer lacca*. Table 1 summarizes the distribution of the species and their important host plants.

Some of the species found in India occur also in other countries. *L. albizziae*, for instance, is found in Ceylon. *L. chinensis* is the chief source of commercial lac in Thailand. Other countries in which *Laccifer* spp. occur include Burma, Cambodia, Laos, North Vietnam, China, Formosa, Indonesia, Philippines, Malaya, Pakistan, Nepal, Sikkim and Bhutan (Green, 1896, 17; Green, *Indian Mus. Notes*, 1903, **5**, 96; Green, 1922, 408–16; Chamberlain, *Bull. ent. Res.*, 1923, **14**, 147; 1925, **16**, 31; Misra, ibid., 1930, **21**, 161; Mahdihassan, *J. Sci. Ass., Vizianagram*, 1923, **1**, 47; Glover, 123–24; Shellac, 9; Kapur, 7–23; Roonwal *et al.*, 7–9).

Life cycle—The insect starts its life as a minute boat-shaped, red coloured larva, *c.* 0.5 mm. long and 0.25 mm. broad. The larvae emerge in large numbers at certain times of the year from the lac cells of the female insect and crawl over the surface of twigs and branches of plants they infest. A healthy female produces 300–1,000 larvae. After a brief period, and depending on favourable weather conditions, the larvae emerge from the cell in search of suitable places for settlement; and larval emergence may continue for several weeks. The proportion of male to female

TABLE 1—LACCIFER SPP. AND THEIR DISTRIBUTION IN INDIA

Species	Host plants	Area recorded
1. *L. albizziae* (Green)	*Croton caudatus* Geiseler and other plants	Darjeeling
2. *L. ambigua* Misra	..	Jhansi
3. *L. chinensis* (Mahdihassan)	*Cajanus cajan* (Linn.) Millsp. and other plants	Assam
4. *L. communis* (Mahdihassan)	*Ficus mysorensis* Heyne and other plants	Mysore
5. *L. ebrachiata* (Chamberlain)	*Ficus elastica* Roxb.	Manbhum & Bangalore
6. *L. fici* (Green)	*Ficus religiosa* Linn., *F. bengalensis* Linn. & *Butea monosperma* (Lam.) Taub.	Monghyr & Coimbatore
7. *L. indicola* Kapur syn. *L. indica* Misra	*Ziziphus mauritiana* Lam.	Bihar
8. *L. jhansiensis* Misra	*Ziziphus mauritiana* Lam.	Jhansi
9. *L. kydia* Misra	*Kydia calycina* Roxb.	Assam
10. *L. lacca* (Kerr)	A number of host plants	All over India
11. *L. longispina* Misra	*Cajanus cajan* (Linn.) Millsp.	Assam
12. *L. mysorensis* (Mahdihassan)	*Shorea talura* Roxb. and other plants	Mysore
13. *L. nagoliensis* (Mahdihassan)	*Schleichera oleosa* (Lour.) Oken	Bangalore
14. *L. pusana* Misra	*Butea monosperma* (Lam.) Taub. & *Ziziphus mauritiana* Lam.	Pusa



Redrawn from Glover

FIG. 1. LAC INSECT (LACCIFER LACCA)—STAGES IN LIFE CYCLE: 1. LARVA 2. MALE CELL 3. FEMALE CELL 4 & 5. WINGLESS AND WINGED MALE ADULTS 6. FEMALE ADULT 7. MATURE FEMALE LAC CELL 8. MALE AND FEMALE LAC CELLS ON BER (ZIZIPHUS SP.) TWIG 9. LAC ENCRUSTATION ON BER (ZIZIPHUS SP.) TWIG

larvae in the brood varies in different crops and years, but generally it is 1 : 3. The density of settlement on the shoots is usually 150–180 larvae/sq. cm. Once settled the larva does not move from its place.

A week or so after settling, the larvae start secreting lac from glands distributed under the cuticle all over the body, except the mouth parts, the two breathing pores and the anus. It thus gets encased in a cell of its own secretion which increases in size with the growth of the insect. The larva moults thrice before reaching maturity ; the duration of each of the three larval stages depends on environmental factors, such as temperature, humidity and host plant. The sex is readily recognized by the shape of the cell even in the early stages of larval development. In the case of the male cell, the growth is more along the longitudinal axis ; in the case of the female cell, the growth is more along the vertical axis. The differentiation between sexes is particularly marked after the first moult. The male lac cell assumes a slipper-like appearance and a loose operculum at the rear end is evident immediately after the second moult. Inside the cell, the larva casts the second moult and passes through prepupal and pupal stages ; during these stages, the larva does not feed and the mouth parts become abortive. After the completion of the pupal stage, the adult male, which may or may not have wings (wingless males are more common) emerges by pushing open the operculum ; the relative numbers of the two forms in a colony vary considerably in different seasons.

The female larva becomes swollen and assumes the form of a pear-shaped or roundish bag which completely occupies the space inside the lac cell. After the final or third moult, the female is sexually mature and is fertilized by the male which has a life of 62–92 hr. after emergence. Lac secretion by the female continues, and the size of the insect as well as that of the enveloping lac cell increases at a fast pace ; the female lac cell eventually attains a size which is several times that of a male lac cell. The female continues to secrete lac until the eggs are laid. Even the unfertilized female is as capable of producing lac and fertile progeny as the fertilized female.

As the time for egg laying approaches, the body of the female contracts on one side (ventral), gradually vacating space inside the lac cell in which it is enclosed. Simultaneously, wax and wax filaments are secreted and shed in the vacated space, possibly to provide dry dressing and cushion for the future young larvae. The anal tubercle is then withdrawn inside

FIG. 2. LAC ENCRUSTED BRANCHES OF KUSUM SCHLEICHERA OLEOSA

the cell for laying eggs, which hatch into larvae immediately after laying. Temperature plays an important role both in egg laying and larval emergence. Egg laying practically ceases if the temperature falls below 17° in summer and below 15° in winter ; the female, however, retains its vitality to lay eggs for 4 to 12 days. The larvae inside the lac cell become inactive below a temperature of 20° ; but their capacity to produce lac subsequently under favourable conditions is not impaired. The percentage of females in the progeny is not affected by subjecting broodlac to low temperature for short periods. These factors have an important bearing on the preservation and transport of broodlac over long distances and on forcing larvae to swarm at particular periods as desired.

Strains of lac insect—Two strains of the lac insect are commonly recognized in India, the *Rangeeni* and the *Kusumi* ; lac crops raised from them are named after the months in which they are harvested. Each strain completes its life cycle twice a year, but the seasons of maturity differ considerably: thus in the

case of *Rangeeni* strain, the *katki* crop is harvested in October–November from inoculations made in June–July; the *baisakhi* crop is obtained in June–July from plants inoculated in October–November. Usually as a general practice the *baisakhi* crop is harvested earlier in April or May as *ari* i.e. in immature state of development. Similarly, in the case of *Kusumi* strain, the *aghani* crop is harvested in January–February from plants inoculated in June–July; the *jethwi* crop is obtained in June–July from January–February infection.

In Mysore State, the *Rangeeni* strain completes three cycles in 13 months on jallari (*Shorea talura*), though the same Mysore strain when grown on jallari in northern India, has only two life cycles in a year. Likewise, *Kusumi* brood raised in northern India when inoculated on kusum trees in Madras State, completes its life-cycle in different months. Equable climatic conditions in the south seem to be responsible for these variations.

Each healthy *Rangeeni* female lac insect in its life time produces *c.* 0.029 g. of lac and each *Kusumi* female, *c.* 0.069 g. To produce one pound of *Rangeeni* and one pound of *Kusumi* lac, 15,655 and 6,580 healthy females respectively are required. The overall production of *Rangeeni* lac is 5–8 times that of *Kusumi* lac, because of the limited numbers and distribution of kusum trees in India. *Kusumi* lac, however, sells at a higher price on account of the superior quality of the resin [Misra, *Bull. agric. Res. Inst. Pusa*, No. 185, 1928; Glover, 4; Kapur, *Indian Fmg, N.S.*, 1954–55, **4**(5), 25; Shellac, 9–16].

Host plants—There are well over a hundred species of plants on which lac insects have been recorded in India, but from the point of view of large-scale lac production, the following are important:

A. *Rangeeni* strain

Palas, dhak [*Butea monosperma* (Lam.) Taub.]—Common throughout the greater part of India, extending in N.W. Himalayas as far as Jhelum; in the outer Himalayas it ascends up to 900 m. and in the hills of southern India up to 1,200 m. It is the commonest lac host in the country.

Ber, beri, kul (*Ziziphus mauritiana* Lam.)—Found throughout the greater part of India, either wild or naturalized, ascending up to 1,500 m. in the Himalayas. It is one of the major hosts in most lac growing tracts; it is the only important lac host in Murshidabad and Malda districts of West Bengal and in Hoshiarpur district of Punjab.

Ghont, kat-ber (*Ziziphus xylopyra* Willd.)—Fairly widely distributed in India; found especially in Rajasthan, Uttar Pradesh, Madhya Pradesh and the Deccan Peninsula from Konkan southwards; it is an important lac host in Madhya Pradesh.

Porho, khunia, jahrphali (*Ficus cunia* Buch.-Ham.)—Found throughout the greater part of India, especially on the sides of ravines. It is valuable for preserving broodlac in hot summers. It is utilized for lac cultivation mostly in Chota Nagpur and Assam; a host plant of potential importance in other parts of India.

Barh, bargad (*Ficus bengalensis* Linn.) and Peepal (*Fiscus religiosa* Linn.)—Found throughout India; these hosts plants are particularly valued in the hotter parts of the country as they are able to carry broodlac through the summer months.

Arhar [*Cajanus cajan* (Linn.) Millsp.]—Extensively cultivated throughout India, it is an important lac host in Assam hills where it is grown as a biennial or triennial crop. In the plains, where it is usually an annual crop, it is of little value for lac cultivation. *Laccifer chinensis*, which is common in Assam, is probably the species that thrives on it.

Tapria siris (*Albizzia lucida* Benth.)—Distributed in the sub-Himalayan tract from Nepal eastwards and in Assam; it is another important lac host in Assam and has given good results in Chota Nagpur. It grows well in several areas in northern India.

Other host plants employed to a small extent in the cultivation of *Rangeeni* strain in different parts of India are: panjan, sandan (*Ougeinia oojeinensis* Hochr.) for *baisakhi* crop; khair (*Acacia catechu* Willd.) for *ari* (premature cutting) of *baisakhi* and *katki* crops; babul, kikar (*Acacia arabica* Willd.) and pansaura (*Grewia serrulata* DC.) both for *baisakhi* and *katki* crops.

B. *Kusumi* strain

Kusum [*Schleichera oleosa* (Lour.) Oken]—Found in the dry forests of the sub-Himalayan tract from Sutlej eastwards and throughout central and southern India. Almost the entire *Kusumi* lac is grown on this host in Chota Nagpur, Madhya Pradesh, Orissa and parts of Mysore and Madras States.

Khair (*Acacia catechu* Willd.)—Common in most parts of India; it has been successfully employed in Chota Nagpur for carrying *aghani* crop. It remains leafless for a considerable period during the summer, and it is most important for lac cultivation that it should occur in association with kusum so that the

latter may be used as host for the *jethwi* crop.

During favourable seasons, when extra broodlac is available, cultivators in Chota Nagpur inoculate khair trees and harvest a satisfactory crop [Misra, *Bull. agric. Res. Inst. Pusa*, No. 185, 1928; Glover, 31–39, 83–87; Negi, *Bull. Indian Lac Res. Inst.*, No. 76, 1948; Kapur, *Indian Fmg, N.S.*, 1954–55, 4(5), 25; Kapur, 14–23; Roonwal *et al.*, 9–140].

Lac Cultivation

Cultivation of lac has been carried on by peasants in forest, sub-forest and hinterland areas where suitable host plants exist, as a subsidiary occupation. The more important areas of lac production are: *Bihar*—Chota Nagpur division, Santhal Parganas and Gaya districts; *Madhya Pradesh*—Bilaspur, Raipur, Balaghat, Chindwara, Jabalpur, Surguja, Mandla, Raigarh, Seoni, Durg, Hoshangabad and Sahdol districts; *West Bengal*—Purulia, Murshidabad, Malda and Bankura districts; *Assam*—Khasi and Jaintia hills, Garo hills, Mikir hills, Nowgong, Kamrup and Sibsagar forest division; *Orissa*—Mayurbhanj, Sambalpur, Bolangir, Dhenkenal, Kalahandi and Keonjhar districts; *Bombay*—Bhandara, Chanda, Panchmahal and Baroda districts; *Uttar Pradesh*—Mirzapur district and Lucknow and Varanasi forest divisions. Small quantities of lac are grown in Punjab (Hoshiarpur dist.), Mysore and Madras (Madurai dist.) States; the lac produced is consumed locally.

Lac cultivation is initiated from broodlac, which is the twig of host tree carrying lac encrustation, with larvae about to emerge from mother cells; the twigs are cut, bundled and tied at convenient places on a fresh host plant, so that the emerging larvae swarm and settle on nearby succulent shoots.

Traditional methods of lac cultivation, however, have not proved always reliable in providing sustained supplies of healthy broodlac for raising two crops a year; optimum yield of lac from a given quantity of broodlac is also not always obtained, and fluctuations in lac production have been the rule in the past. The proper management of the host stock, use of pest-free brood, time and manner of inoculating host plants and control of pests and predators of the lac insect are all important for ensuring good yields of lac. In recent years, much information of value to lac culture has emerged as a result of researches at the Indian Lac Research Institute at Namkum, Bihar. Improved techniques of cultivation have been evolved and efforts are being made to popularize them among lac growers.

TABLE 2—PRUNING TIME FOR COMMON LAC HOSTS

Host	Lac crop	Time of pruning
Palas and Ber	*Katki*	Early to mid-February
do.	*Baisakhi*	Early to mid-April
Kusum	*Aghani*	January-February (1½ years before infection)
do.	*Jethwi*	June-July (1½ years before infection)
Khair	*Katki*	February
do.	*Aghani*	Mid-April to mid-May

Pruning—The bulk of lac crop is grown on host trees, mostly kusum, palas and ber. The nature and extent of pruning of host plants and the time of the year at which pruning is effected have an important bearing on the production of succulent feeding ground for the lac insect and therefore on the lac crop. Table 2 gives the times of pruning for different host plants. It may be necessary, however, to modify pruning schedules according to local conditions.

Cropping of host trees like kusum and certain species of *Ficus* at the time of harvesting, also serves the purpose of pruning. In pruning or cropping a tree, the overall consideration should be that the general health of the tree must be maintained and its frame increased as far as possible. All dead and diseased branches should be cut off. It is inadvisable to cut branches over 5 cm. in diam. Branches less than 1.25 cm. in diam. should be cut close to the place of origin by using sharp implements, like a secateur (roll cut type), but for branches which cannot be reached by hand, a standard tree pruner may be used. For cutting thicker shoots or dead stumps, a country *dauly* (crooked knife) is useful. If a stump has to be left, it should not be less than 45 cm. in length and 1.25 cm. in diam. near the base.

Coupe system—If the same tree is continuously inoculated its vitality suffers and the yield of crop progressively diminishes. It is, therefore, important that host plants should be given periodic rest. The coupe system of cultivation provides for the maximum use of host plant resources consistent with their vigour and well being.

Available host trees are divided into blocks or coupes, the size and number of which are determined by the kind of trees and the strain of the lac insect. Each coupe is inoculated according to a schedule. Kusum tree is slow-growing and should be normally inoculated after an interval of 1½ years.

As the crop lasts for 6 months, the available number of trees are divided equally into four coupes and infected by turn. Each coupe yields a crop once in two years.

In the case of palas, ber and most other hosts of *Rangeeni* strain, the total available number of trees are divided into three coupes in the ratio of 1:3:3. The smaller coupe, which may be located more centrally for convenience of operation, is employed for growing only the *katki* crop which is of three to four months' duration and for which trees are inoculated in June–July. The other two coupes are utilized for growing the *baisakhi* crop, only one of these being put under lac in each alternate year. The *baisakhi* coupe is inoculated in October–November and the crop matures in the following June–July: it is usually partially harvested: shoots covered with dead lac (often caused by excessive heat) and shoots which are almost fully covered with living lac encrustations are cut, while shoots bearing sparse settlements of insects are allowed to remain. In the latter case, swarming of lac larvae will take place *in situ* and a small *katki* crop is obtained. Good encrustations of insects are used as broodlac for inoculating the *katki* coupe.

In hot localities, cultivation on palas and ber may be done on a two-coupe system. Various host trees can also be worked in alternation or combination. *Ficus* spp. and other plants that put forth new leaves during summer should be used to grow *baisakhi* and *jethwi* crops.

Inoculation—Broodlac should be cut just before the commencement of larval emergence. This is determined visually by the appearance of yellow spots on encrustations at the anal regions of healthy females. The spots gradually increase in size and become orange. When the spots are about a quarter of the size of the lac cell, the twigs are cut: emergence of larvae will begin *c.* 5 days later. Inoculation of fresh host plants should be completed before larval emergence. Only thick encrustations, free of any sign of pest attack, should be selected as broodlac.

Branches or twigs bearing healthy broodlac should be cut into convenient lengths of 15–30 cm. and tied with strings to succulent shoots of the host tree either singly or in small bundles. The tying is done either longitudinally or laterally, or brood sticks may be interlaced among branches. Longitudinal inoculation allows maximum contact between brood and host. In lateral inoculation, brood sticks are tied across the gap between two host shoots. Inoculation by interplacing is practised where new shoots arise in a close group from a parent branch.

The quantity of broodlac required for a tree depends upon the kind of tree and the size and number of suitable branches. Approximate weights of broodlac required for inoculating one medium-sized tree of the following hosts are: Palas, 0.5–1.0 kg.; ber, 1–2 kg.; khair, 1–2 kg.; kusum, 5–10 kg.

Preservation of broodlac—Successful lac cultivation depends on the continuous availability of broodlac in the required quantities. Since different host plants react differently to weather conditions, the broodlac survives better on some host species than on others. This is especially true in the case of hosts during hot summers. In order, therefore, to ensure a steady supply of broodlac, it is advisable to have a large variety of trees under lac wherever possible rather than restrict cultivation to one host. A shortage of broodlac periodically occurs in areas where only one host, ber or palas, is exploited for lac production. These two hosts between themselves account for 80% of the annual lac production in India and being deciduous, they remain leafless for a long period during summer, thus exposing the lac insect to heat, drought and hot winds. In order to overcome this difficulty in areas where only palas or ber is available resort may be had to partial pruning of ber and partial defoliation of palas in October–November just before inoculating the plants. As a result, the trees put forth new leaves which last during hot months and provide shade to the maturing *baisakhi* brood.

The second way of preserving adequate brood during the hot summer months is to select only hosts which normally have green leaves during summer for raising the *baisakhi* crop. Certain *Ficus* spp., notably *F. cunia* and *F. lacor,* and a few leguminous plants like *Albizzia lucida* and *Ougeinia oojeinensis* have proved valuable for this purpose.

Alternation of brood—If broodlac from a particular host is used year after year in the same locality and on the same host species the quality of the lac crop is likely to deteriorate. It would be advantageous, therefore, to exploit more than one kind of host for cultivating lac. Khair (*Acacia catechu*), which is more or less widely distributed, is a host for both *Rangeeni* and *Kusumi* crops and can be successfully alternated with kusum. Sticklac obtained from khair trees inoculated by kusum brood is as good in quality as that raised on kusum, and it fetches about the same price.

Parasites & Predators—Several species of parasitic chalcidoid wasps lay their eggs in or on the body of the lac insect. The grubs on hatching out feed on the lac insect and mature adult chalcidoids emerge from the lac cell by chewing out circular holes. The damage resulting from parasites is usually 5–10% of the lac crop, but in certain years and in some localities it may be as high as 50%.

Predators of lac insect which are of serious consequence are two moths, *Eublemma amabilis* Moore and *Holcocera pulverea* Meyr., and three species of *Chrysopa* Leach (lacewing fly), viz. *C. madestes* Banks., *C. lacciperda* Kimmins., and an unidentified species. The caterpillars of the two moths tunnel through and eat away lac encrustations as well as the insects, thus causing considerable damage to the crop. *E. amabilis* caterpillars build galleries and domes with silk and roundish pink coloured discs of their excreta, while damage by *H. pulverea* caterpillars can be recognized by the irregular webs studded with excreta. *E. amabilis* has six generations in a year while *H. pulverea* has five. The larvae of *Chrysopa* spp. suck the body fluids of the lac insect, but do not feed on lac. The damage caused by predatory insects amounts to about 40% of the lac crop. Besides these and a few other minor insect enemies, birds and squirrels cause serious damage to living insects and lac encrustations during summer.

Measures for the control of insect pests of lac are: (*i*) immersion of freshly harvested sticklac, not wanted for brood, as well as *phunki* lac (i.e. broodlac after larval emergence is complete) in running or deep stagnant water; (*ii*) scraping of lac from twigs immediately after harvesting and killing larvae and pupae of the pests by burning, crushing, drowning or by fumigation with carbon bisulphide (1 oz./10 cu. ft. of space) before storage; (*iii*) avoiding cultivation of early and late maturing varieties of lac, at least for brood purposes, in the same locality to prevent the spread of pests; and (iv) encasing of broodlac for inoculation in 60–80 mesh wiregauze baskets, *c.* 30 cm. × 7 cm. in size. The last method is particularly recommended for areas where lac cultivation is being introduced for the first time. The baskets permit free exit to lac larvae but exclude enemy insects. Proper management of host plants with a view to ensure their vitality and vigour helps to reduce damage by parasites.

Parasites and predators emerge from lac cells in large numbers towards the close of the emergence of lac insect larvae. The practice of leaving broodlac on trees even after swarming is complete, therefore, favours the spread of enemy insects. To reduce the risk to the minimum, removal of *phunki* lac from inoculated trees should be completed as early as possible, i.e. within 2–3 weeks of the date of swarming. For the same reason, self or natural inoculation of host trees should be avoided except where absolutely necessary.

Beneficial insects—Some insects are indirectly beneficial to lac cultivation in as much as they keep off or parasitise enemy insects. Some ants act as bodyguards of the lac insect, while a few destroy larvae of lac pests. Beneficial insects may belong to the groups of chalcids, braconids, ichneumonids and bethylids. They parasitise the eggs or larvae of *Eublemma amabilis* and *Holcocera pulverea.* Their utility in controlling lac pests is, however, limited, because their prevalence in proportion to enemy insects is small.

Harvesting & Yield—The instruments used for harvesting lac crops are those normally used for pruning; in fact, if harvesting is properly done there is no necessity for pruning the hosts.

Lac required for brood purposes is cut a few days before larval emergence; broodlac meant for despatch over long distances to other lac growing centres is cut a week or so before emergence. For despatch to outside stations by motor, rail or air, broodlac is packed in bamboo baskets with a capacity of 15–20 kg.

Encrustations of lac from excess crop (not required for brood) are separated from the twigs by scraping. The scraped material, green lac or sticklac, as it is called, is spread thinly (10–15 cm. deep) in a covered and well-ventilated place and periodically raked until dry. Broodlac twigs employed for inoculating fresh host plants, are collected after the completion of swarming, and encrustations from them are also scraped out and dried. The sticklac thus obtained is then bagged for storage or for the market. Lac should not be stored in the green condition as fermentation sets in and fungus growth is favoured; lumps are formed and the quality of lac deteriorates. Long storage of even dried lac affects the solubility and other properties of lac and reduces its market value.

The yield of lac is 2½–3 times the weight of broodlac employed for inoculating the host; in really good crops, it may be as high as 5–7 times. The yield of scraped lac is usually about one-third of the harvested material (which includes twigs) in the case

of *Rangeeni* crops and about one-half in the case of *Kusumi* crops [Misra, *Bull. agric. Res. Inst. Pusa*, No. 185, 1928; Glover, 23–62, 66–115; Negi, *Bull. Indian Lac Res. Inst.*, No. 50, 1942, 1–7; No. 76, 1948, 1–10; Negi *et al.*, ibid., No. 63, 1945, 1–12; Kapur, *Indian Fmg, N.S.*, 1954–55, **4**(5), 25; Shellac, 25–34].

Composition & Uses of Lac

The major constituent of sticklac is the resin (70–80%); other constituents present are: sugars, proteins, and soluble salts, 2–4; colouring matter, 1–2; wax, 4–6; sand, woody matter, insect bodies and other extraneous matter, 8–12%; a volatile oil is present in traces (Ranganathan, *J. sci. industr. Res.*, 1944–45, **3**, 20; *Annu. Rep. Indian Lac Res. Inst.*, 1947–48, 20; 1948–49, 21).

Lac resin (mol. wt., *c.* 1,000; acid val., 59–75; hydroxyl val., 255–280; sap. val., 225–230) is composed of interesters of hydroxy fatty acid derivatives. Aleuritic acid (trihydroxypalmitic acid, $C_{16}H_{32}O_5$, m.p. 101°) is the major constituent; several isomers of aleuritic acid are present. Shellolic acid ($C_{15}H_{20}O_6$), a dihydroxy hydroaromatic acid, occurs to the extent of 10%: two isomeric shellolic acids (m.p. 206° and 238°), two isomers of dihydroshellolic acid (m.p. 226° and 245°) and two isomers of the next higher homologue of dihydroshellolic acid (m.p. 166° and 226°) have been isolated. Other acid constituents present in lac are kerrolic acid ($C_{16}H_{32}O_6$, m.p. 132°) and butolic acid ($C_{15}H_{30}O_3$, m.p. 54–55°); the former is a tetrahydroxy-hexadecanoic acid, while butolic acid is a monohydroxy-pentadecanoic acid (Ranganathan, loc. cit.; Kirk & Othmer, XII, 247–49; Sen Gupta & Bose, *J. sci. industr. Res.*, 1952, **11B**, 458).

The resin can be fractionated into soft and hard components by exhaustive extraction with ether; the former constitutes *c.* 30% of the original resin and is brown in colour. Both soft and hard resins can be further fractionated by successive extraction with organic solvents. One fraction of soft resin contains free acids and neutral materials including the yellow dye, erythrolaccin. The second fraction possibly comprises interesters of equivalent amounts of aleuritic acid, an isomer of aleuritic acid and lacollic lactone. Mono- and dihydroxy-palmitic acids, butolic acid, a liquid lactonic acid and two solid acids (m.p. 149° and 225°) have been identified in the soft resin. The largest fraction (50%) of the hard resin consists of a monobasic interester ($C_{32}H_{54}O_9$) which on saponification yields equimolar proportions of aleuritic acid and lacollic lactone; the latter is a mixture of several constituents but has the properties of a single hydroxy acid lactone of the composition $C_{16}H_{24}O_5$. The second largest fraction (25%) is composed of interester lactones of equivalent amounts of aleuritic acid, lacollic lactone and kerrolic acid (Kirk & Othmer, XII, 250).

Wax—The wax present in sticklac is usually obtained as a by-product in the manufacture of dewaxed shellac; it is known in the trade as Shellac Wax. The analytical constants of the wax fall within the following ranges: m.p. 72–82°; $d^{15.5°}$, 0.971–0.982; acid val., 12.0–24.3; sap. val., 79–126; ester val., 45.5–104.0; and iod. val., 6.8–8.8. It contains: esters (ceryl lignocerate, ceryl cerotate, lacceryl lacceroate, ceryl aleuritate), 80–82; acids (lacceroic, cerotic), 10–14; alcohols (neoceryl, lacceryl), 1; hydrocarbons (pentacosane, heptacosane), 2–6; and resins, 2–4%. It resembles carnauba wax and although it is useful in formulations where a natural wax of the hard type is desired, its principal use is in the electrical industry (Warth, 110–13).

Colouring matter—Lac contains a water soluble red dye, laccaic acid, and an alkali and spirit soluble yellow dye, erythrolaccin; the latter is possibly a tetrahydroxymethyl anthraquinone. Laccaic acid ($C_{20}H_{14}O_{10}$, m.p. 180° decomp.) is a hydroxy-anthraquinone carboxylic acid. Lac dye is obtained by extracting sticklac with water and sodium carbonate solution and precipitating with lime. It gives bright red and scarlet shades which are somewhat faster than cochineal (Mayer & Cook, 144–47; Ranganathan, loc. cit.).

Refining—Crude lac, as obtained by scraping the resinous encrustations from harvested twigs, is known in commerce as sticklac. It is seldom used without refining.

Sticklac is crushed by hand- or power-operated roll mills and washed with water in cup-shaped stone vats or steel barrels. It is then dried on cemented floors away from the direct rays of the sun and finally winnowed. The water soluble colouring matter is removed during washing. Washed lac or seedlac, thus obtained is in the form of grains (10 mesh/in. or less), yellow or reddish brown in colour. Adhering impurities amount to 3–10%.

The impurities are eliminated from seedlac by further treatment—not filtration of molten material or by dissolution in a suitable solvent. Varieties of refined lac met with in the trade are: shellac, button lac, garnet lac, dewaxed lac, etc. (For details relating

to the refining of lac see Wlth India—Industrial Products, pt V, 162–74).

Utilization—Lac is one of the most versatile natural resinous materials. It has a unique combination of properties which renders it useful for a variety of applications in the plastics, electrical, adhesive, leather, wood finishing, hat manufacturing and other industries. It is thermoplastic; it is soluble in alcohol and weak alkalies, and lac films are resilient, possess high scratch-hardness, good adhesion and electrical insulation.

Lac dye was formerly employed extensively for dyeing silk, wool and leather; it has now been largely replaced by the more versatile synthetic dyestuffs.

The chief use of lac was in the manufacture of gramophone records; 30–40% of the shellac exported from India was being consumed by this industry in the past. In recent years, lac is being replaced, particularly in U.S.A., by synthetic substitutes. The annual consumption of lac in India, for this purpose, is reported to be 250 tons.

Lac is used in the electrical industry in the form of insulating varnishes and moulded insulators. The largest use is in the manufacture of micanite and impregnating components, laminated paper insulation, mica insulation products, switch bases and boards, spark shields, etc. It possesses very good adhesion to mica; its non-tracking property, i.e. freedom from surface carbonization as well as expansion of conducting tracks under silent or high voltage discharge, makes it particularly useful for applications in the electrical industry.

By far the biggest consuming channel for lac is the surface coating industry; it is used in the form of varnishes, polishes, finishes, lacquers, etc. for protective and decorative purposes. Spirit varnishes are employed for finishing wooden floors, furniture, musical instruments, sports goods and toys. Lac is used as a coat for metal ware to prevent tarnishing, for preserving archaeological and zoological specimens, and for finishing playing cards, rubber cloth and oil cloth, oil silk, linoleum and a variety of other articles. It is used also for coating and finishing earthenware utensils to render them impermeable to water. Aqueous varnishes or emulsions are used for leather dressing and leather finishing and as coatings for medicine tablets.

Lac is used for stiffening and finishing felt hats, straw hats and silk hats; no synthetic resin has so far been formulated to replace lac for this purpose. It is the principal ingredient of sealing wax. It is a minor but important ingredient in rubber mixes, particularly those used for shoe heels and soles, tyres, tubes, rubberized fabrics, etc. It is used also in various types of adhesives and cements. It is used for glazed paper, printing and water-proof inks, nail polishes, dental plates, ammunition, bangles, jewellery fittings, photo engraving, wax crayons and optical frames (Misra, *Bull. agric. Res. Inst. Pusa*, No. 185, 1928; Sen & Ranganathan, 17–71).

TABLE 3—AVERAGE ANNUAL PRODUCTION OF LAC IN DIFFERENT STATES (1951-60)

(Qty in thousand md.)

	Baisakhi	*Jethwi*	*Katki*	*Aghani*	Total
Bihar	331.5	10.9	89.8	32.4	464.6
Madhya Pradesh	214.6	9.4	108.1	16.7	348.8
West Bengal	132.8	4.2	24.8	14.5	176.3
Maharashtra	24.7		25.0		49.7
Gujarat	6.2		6.2		12.4
Uttar Pradesh	13.3		4.3		17.6
Orissa	2.8		2.1	8.7	16.8
Assam	..		11.5	..	11.5
Other States	8.7	0.3	3.9	0.9	13.8
Total	734.6	28.0	275.7	73.2	1,[illegible].5

TABLE 4—PERCENTAGE SHARES OF DIFFERENT STATES IN TOTAL LAC PRODUCTION*

	1951–52	1952–53	1953–54	1954–55	1955–56	1956–57	1957–58	1958–59	1959–60†	Average (1951–60)
Bihar	36.6	36.7	40.0	49.9	46.5	45.8	31.3	42.2	46.8	41.8
Madhya Pradesh	33.0	26.1	27.4	23.8	30.3	29.0	42.2	38.7	30.8	31.4
West Bengal	19.4	25.3	22.3	16.8	14.3	15.3	12.7	6.0	12.1	15.9
Maharashtra	5.8	4.3	3.0	2.2	4.0	4.3	6.6	5.7	3.1	4.5
Gujarat	1.5	1.1	0.8	0.6	1.0	1.1	1.6	1.4	0.8	1.1
Other States	3.7	6.5	6.5	6.7	3.9	4.5	5.6	6.0	6.4	5.3

* Indian Lac Cess Committee, Ranchi. † Data provisional.

TABLE 5—PRODUCTION OF LAC*
(in thousand md.)

	Baisakhi	*Katki*	*Aghani*	*Jethwi*	Total
1935 36 to 1939 40 (av.)	808	327	165	48	1,348
1940 41 to 1944 45 (av.)	730	251	119	62	1,162
1945 46 to 1949 50 (av.)	690	283	135	58	1,166
1950 51	744	283	41	5	1,073
1951 52	957	267	63	9	1,296
1952 53	929	156	38	29	1,152
1953-54	427	161	51	15	654
1954-55	600	220	158	45	1,023
1955-56	813	333	61	41	1,248
1956 57	732	501	65	17	1,315
1957 58	840	233	40	27	1,140
1959 59	600	252	45	30	927
1959-60	650	345	129	35	1,159

* *Silver Jubilee Souvenir*, Indian Lac Cess Comm., 1956, 189 209; *Atlas of Indian Lac*, Indian Lac Cess Comm., 1959, 14, 18.

TABLE 6—PERCENTAGE SHARES OF DIFFERENT CROPS IN TOTAL LAC PRODUCTION*

	Baisakhi	*Jethwi*	*Katki*	*Aghani*
1951 52	73.8	0.7	20.6	4.9
1952 53	80.6	2.5	13.5	3.4
1953 54	65.2	2.4	24.6	7.8
1954 55	58.6	4.4	21.4	15.6
1955 56	65.1	3.3	26.7	4.9
1956 57	55.7	1.3	38.0	5.0
1957-58	73.7	2.4	20.4	3.5
1958-59	65.5	3.2	26.2	5.1
1959 60**	56.1	3.0	29.8	11.1
Average (1951-60)	66.0	2.6	24.6	6.8

* Indian Lac Cess Committee, Ranchi. ** Data provisional.

Production & Trade

Lac is grown in India mostly as a subsidiary crop by small village farmers and the individual production often ranges from a few pounds to a maund.

The average annual production of lac in India during past 30 years is over 11 lakh maunds. Table 3 gives the State-wise annual production for each of the four lac crops during 1951–60. Table 4 gives the percentage shares of various States during the period 1951–52 to 1959–60 (Sharan & Sundaram, *Silver Jubilee Souvenir*, Indian Lac Cess Comm., 1956, 74; *Atlas of Indian Lac*, Indian Lac Cess Comm., 1959, 14).

Baisakhi crop—This crop accounts for c. 66% of the total annual production and receives particular attention from growers and trade alike. Failure of this crop is not as frequent as that of others. The maximum annual production of *baisakhi* crop was 11,13,000 md. (1939–40) and the minimum, 3,65,350 md. (1943–44). Bihar accounts for the major share of the production (45%) followed by Madhya Pradesh (29%) and West Bengal (18%).

Katki crop—This crop constitutes c. 25% of total annual production. During the period 1930–60, the maximum production was 5,01,000 md. (1956–57) and the minimum, 1,39,250 md. (1932–33). As the *katki* crop supplies brood for the next *baisakhi* crop, an increase or decrease in the former is generally followed by similar variations in the *baisakhi* crop.

Bihar contributes 32%, Madhya Pradesh 39%, Assam 4% and West Bengal 9% to the total production of *katki* crop. Assam produces only the *katki* crop, while this crop also occupies an important position in Madhya Pradesh.

Jethwi crop—The *jethwi* crop, on an average, constitutes only 2.6% of the total annual production; Bihar accounts for 40% of the total *jethwi* crop and Madhya Pradesh, for 34%. This crop supplies broodlac to the *aghani* crop, the prospects of which are eagerly awaited by the trade, because of the high prices that it fetches in the market. Since the period of development of *jethwi* crop falls during the summer, it is particularly liable to failure.

Aghani crop—This crop accounts for c. 6.8% of the total annual lac production, of which c. 44% is produced by Bihar and 23% by Madhya Pradesh. During the period 1930 to 1960, the highest production was 3,82,250 md. (1936–37) and the lowest, 38,500 md. (1952–53).

Tables 5 and 6 give the production of lac from various crops and the percentage shares of these crops in total lac production.

Marketing—The producers of lac usually sell their crops in the nearest rural market (*haat*) to dealers or agents of manufacturers. Rural markets, small or large, are scattered throughout the lac growing areas and number over 600 in Bihar, 850 in Madhya Pradesh, 125 in West Bengal and 300 in Assam. With

the approach of the cropping season, small amounts of rather immature lac start coming into the market; then comes the main flush of crop spread over nearly two months, followed by decreasing quantities.

In normal years, there is usually a carry-over of sticklac of all kinds, but mostly from *baisakhi* and *katki* crops. The quantity carried over depends upon the size of the crop and the export during the year, and it has a marked influence on the price of the new crop. The cultivator keeps himself informed about price fluctuations, but has little holding capacity.

Exports—At present, lac is primarily an export commodity and the internal consumption forms only 5–8% of the total production. Lac is exported mostly in the form of seedlac, shellac and buttonlac; small quantities of sticklac, *kirilac* and refuse lac are also exported. Shellac and buttonlac constitute 58–72% of the export, seedlac, 22–34% and sticklac 0.2–1.3%. Table 7 gives the total annual exports of different kinds of lac along with their values. Table 8 gives the exports to different countries. U.S.A. is the chief importing country followed by U.K.

Imports—Till recently India used to import lac from Burma and Thailand. Burma, in the pre-war years, produced annually c. 54,000 md. of sticklac, all of which was exported to India. During the war and also in subsequent years, Burma did not export any lac. Thailand also exported all its sticklac to India in pre-war years. Since the war, however, the pattern of lac trade with Thailand has completely changed, and India is no longer the only country to which lac is exported by that country. Table 9 gives the annual imports during the last 5 years.

Prices—The average price of *Golden Kusumi* seed-

TABLE 7—EXPORT OF LAC FROM INDIA
(Qty in thousand md. and value in lakh Rs.)

	Shellac & Buttonlac		Seedlac		Sticklac & other kinds		Total	
	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.
1931-39 (av.)	564.0	147.5	229.0	43.5	52.0	4.0	845.0	195.0
1946-56 (av.)	483.0	682.0	240.0	269.0	70.0	45.0	793.0	996.0
1956-57	511.6	688.4	191.5	214.5	66.1	44.2	769.2	947.1
1957-58	413.5	429.6	290.8	242.0	35.7	14.4	740.0	686.0
1958-59	319.5	300.6	359.7	264.1	34.4	9.6	713.6	574.3
1959-60	379.8	383.2	308.9	237.4	41.6	16.0	730.3	636.6

TABLE 8—EXPORT OF LAC TO DIFFERENT COUNTRIES
(Qty in thousand md.)

	1930/31 to 1939/40 (av.)	1946/47 to 1955/56 (av.)	1956-57	1957-58	1958-59	1959-60
U.S.A.	340.0	351.0	225.9	302.1	332.9	308.2
U.K.	208.2	176.6	143.2	107.8	76.2	90.8
Germany	59.0	63.5	102.4	77.8	86.5	82.8
Italy	7.0	19.3	29.6	21.2	15.6	17.3
France	18.0	18.0	21.1	12.1	14.7	15.1
U.S.S.R.	1.2	28.0	61.9	23.8	51.7	20.6
Australia	7.6	14.7	14.2	14.3	11.9	13.8
Japan	50.2	9.2	12.2	15.0	13.2	10.9
Argentina	4.8	8.3	21.0	10.8	5.8	10.8
Brazil	5.2	15.3	18.5	12.5	4.0	26.4
Sweden	5.0	13.1	5.3	5.9	4.3	5.0
China	3.2	5.5	0.1	34.2	26.6	48.1
Netherlands	32.7	8.6	7.9	4.9	4.0	5.8
Hongkong	2.7	10.0	7.6	4.0	4.1	7.0

TABLE 9—IMPORT OF LAC
(Qty in thousand md and value in lakh Rs.)

	Qty	Val.
1955-56	54.5	44
1956-57	48.1	43
1957-58	5.4	3
1958-59	(a)	(a)
1959-60	0.9	0.4

(a) Negligible

lac during 1946–1956 varied from Rs. 143 to Rs. 166/md.: that of ordinary *Baisakhi* seedlac, from Rs. 108 to Rs. 141/md. The prices have since declined considerably. The average price of *Golden Kusumi* seedlac during 1959 was Rs. 99.33/md. The minimum and maximum export prices for some of the grades of seedlac during 1959–60 were: *Golden Kusumi*, Rs. 95, Rs. 115; *No. 1 Kusumi*, Rs. 80, Rs. 100; *No. 2 Kusumi*, Rs. 75, Rs. 93; *Golden Baisakhi*, Rs. 80, Rs. 100; and *Genuine Baisakhi*, Rs. 62 and Rs. 78/md. respectively (Information from Indian Lac Exporters Association, Calcutta).

Lac Tree — *see* **Schleichera**

Lacquer Tree, Burmese — *see* **Melanorrhoea**

LACTUCA Linn. (*Compositae*)

A large genus of annual or perennial herbs, chiefly of north temperate regions. About 25 species occur in India. The limits of the genus, however, have been variously interpreted and some of the species have been transferred to other genera [Stebbins, *Indian For. Rec., N.S., Bot.*, 1939, **1**(6), 237].

All the species contain a milky latex and the dried latex from some of them furnish the drug, Lactucarium. One species, *L. sativa*, is cultivated throughout the world as a salad crop.

L. sativa Linn. syn. *L. scariola* Linn. var. *sativa* C. B. Clarke (Fl. Br. Ind.) GARDEN LETTUCE

D.E.P., IV, 578; Fl. Br. Ind., III, 404.

HINDI & BENG.—*Kahu, salad*; TEL.—*Kavu*; TAM.—*Salattu*.

An erect, glabrous, herbaceous annual, 0.5–1.2 m. high, widely grown for its crisp, edible, highly developed radical leaves, which appear before the flowering starts. Leaves 12.5–25.0 cm. long, thin, nearly orbicular, oblong, obovate or lingulate, plane, bullate or curled: flower heads of yellow rays, borne on panicles; achenes lenticular-oblong, dark brown or greyish brown, with slender beak and white pappus.

The garden lettuce is considered to have originated in the warmer temperate parts of western Asia, including eastern Mediterranean, and descended from *L. serriola* Linn., PRICKLY LETTUCE, found wild in the Himalayas and north temperate regions of the Old World. The two cross readily and according to some, the garden lettuce is only a cultivated variety of the wild species and cannot be assigned a specific rank (Vavilov, 34, 36; Burkill, II, 1295; Thompson & Kelly, 256).

Three or four common cultivars of garden lettuce are generally recognized; they are: 'Capitata' (CABBAGE or HEAD LETTUCE) with cabbage-like round and compact heads; 'Longifolia' (Cos or ROMAINE LETTUCE) forming cylindrical or conical heads with narrow pointed leaves; and 'Crispa' (GATHERING LETTUCE, CURLED LETTUCE or LEAF LETTUCE) with a loose rosette of curled and finely cut leaves, the lower of which are picked as they mature. 'Angustana' (ASPARAGUS or STEM LETTUCE), which resembles the Cos type, is little known in this country; it does not form a thick head and is grown for its thick stem. A large number of horticultural types belonging to different cultivars

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FIG. 3, LACTUCA SATIVA—IN FLOWER

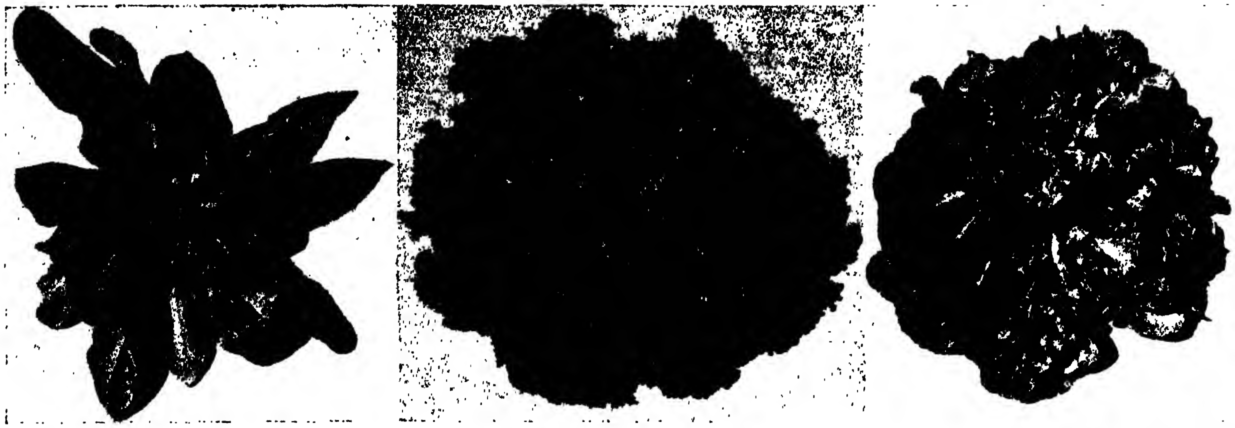

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FIG. 4. LACTUCA SATIVA—DIFFERENT TYPES OF LETTUCE

are under cultivation. They differ from one another in their adaptation to conditions under which lettuce is grown and the quality of crop obtained. Two high yielding types of head lettuce, one with green and the other with yellowish green foliage, have been selected in the Punjab. The following types have been recently recommended for cultivation: Imperial-847, May King, Paris White Cos and Chinese Yellow [Hector II, 1117; Thompson; *Fmrs' Bull. U.S. Dep. Agric.*, No. 1953, 1951; Helm, *Kulturpflanze*, 1954, **2**, 72; Purewal, 25; Choudhri, 130; Gopalaswamiengar, 542; Singh *et al.*, *Indian Hort.*, 1955–56, **1**(1), 29].

Lettuce is grown mostly as a cold weather crop in the plains of India; in the hills, however, it can be grown anytime during spring or early summer. The heading types require a relatively low average temperature, particularly during the later part of their growing period. A monthly mean temperature of 13–16° is considered ideal. The crop thrives well in open situations, in rich and heavily manured soil, plentifully supplied with water when the weather is dry. Fertile loams liberally supplied with well-rotted organic manure at 20 cart loads per acre are very well suited for their cultivation. Application of a complete fertilizer (2 md./acre) containing equal parts of nitrogen, phosphoric acid and potash, in addition to organic manure, is considered helpful (Thompson & Kelly, 256–57; Thompson, loc. cit.: Knott, 220: Gollan, 45–46; Purewal, 27).

Lettuce seeds may be sown directly in the field or seedlings may be raised in nursery beds and transplanted in the field. Seeds are very small (600–700/g.) and should be sown shallow in properly prepared seed-beds to assure germination. For direct sowing, seeds are distributed on the sides of raised beds, 2 ft. wide and 1–2 ft. apart. During the main season, sowings are usually made in nursery beds and seedlings transplanted, when about 6 weeks old in rows 15 in. apart, the distance between plants being 12 in. About 2–2½ lb. of seeds are used per acre. The seeds germinate in 4–5 days after sowing and nearly 85% germination is possible if the seeds are good. Since lettuce is shallow rooted, it requires frequent cultivation to prevent weed growth. It also needs irrigation once every 4–5 days if the weather is dry (Purewal, 27; Milne *et al.*, 98; Gollan, 46; Thompson, loc. cit.).

Two diseases of lettuce have been recorded in India. Of these yellow mosaic, affecting the leaves, is the more widespread. Leaves turn pale yellow and mottled and later get distorted, thickened and leathery. The causative virus is seed-borne and is spread by insects. Use of clean seeds from healthy plants and elimination of infected plants as soon as the symptoms are recognized, are effective as control measures. Pythium leaf rot, caused by *Pythium aphanidermatum* (Edson) Fitzpatrick, affects the lower leaves touching the ground. The incidence of the disease decreases with decrease in moisture (Thompson & Kelly, 264–67; Thompson, loc. cit.; Vasudeva *et al.*, *Curr. Sci.*, 1948, **17**, 244; Jain, *Sci. & Cult.*, 1951–52, **17**, 258).

Leaf lettuce may be harvested at any time after the plants are large enough for use, but before the leaves become tough and bitter. When grown for home use, the large leaves are removed as they mature, leaving the small ones to develop. Head lettuce is ready for harvest when the heads feel solid to the touch and before the flowering stalk begins to develop. A method sometimes adopted to retard early flower stalk development is to cut the tap root below

the ground level and tie the leaves together loosely with a string. A yield of 100-125 md. of heads per acre is reported (Thompson & Kelly, 268; Knott, 223; Gollan, 46; Macmillan, 310; Milne *et al.*, 99; Thompson, loc. cit.).

For seed production, fully naturalized and selected stock should be used. Seeds of the best quality are obtained from plants sown about the later part of October. Seeds rapidly lose their viability under warm moist conditions. They should be stored in a cool dry place (Purewal, 27; Gollan, 45; Thompson, loc. cit.).

Lettuce is a popular salad crop, though it is not so extensively used in India as in western countries. It is sometimes boiled and consumed or converted into a kraut. It is somewhat bitter when grown early, but heads from the main season crop are crisp, juicy and appealing to taste. If the leaves are coarsely cut and thoroughly wetted with sugared milk before use, the taste is much improved (Purewal, 27; Thorpe, VII, 276).

In nutritive value, lettuce is classed along with cauliflower, celery and asparagus. It is valued chiefly for its vitamin and mineral contents. Analysis of fresh lettuce gave the following values: moisture, 92.9; protein, 2.1; ether extr., 0.3; fibre, 0.5; carbohydrates, 3.0; and mineral matter, 1.2%; carotene (as vitamin A), 2,200 i.u.; vitamin B_1, 270 μg.; nicotinic acid, 0.4 mg.; riboflavin, 120 μg.; and vitamin C, 15 mg./100 g. It is also a fair source of folic acid and contains some vitamin E, vitamin G, vitamin K and choline (Whitaker & Bohn, *Econ. Bot.*, 1953, **7,** 243; *Hlth Bull.*, No. 23, 1951, 34; *Sci. News Lett., Wash.*, 1951, **59,** 297; *Chem. Abstr.*, 1940, **34,** 3839; Ahmad *et al.*, *Indian J. med. Res.*, 1953, **41,** 441).

The mineral constituents present in lettuce are: sodium, 3.1; potassium, 208; calcium, 25.9; magnesium, 9.7; iron, 0.73; copper, 0.15; phosphorus, 30.2; sulphur, 11.8; and chlorine, 39.5 mg./100 g. Traces of arsenic, barium, manganese, titanium, zinc, aluminium, fluorine and iodine are reported: availability of lettuce calcium in comparison with that of milk calcium, 80%. Lettuce also contains pectic substances (4% as calcium pectate) and organic acids (oxalic, 0.011; malic, 0.06; and citric, 0.05%) mostly as salts (McCance & Widdowson, 89; Thorpe, VII, 276-77; Jacobs, II, 1252; Kertesz, 306).

Damaged heads and outer leaves are used as cattle feed. An oil rich in carotene, chlorophyll and xanthophyll has been obtained from lettuce waste by extraction with organic solvents; the unsaponifiable fraction of lettuce lipids contains ceryl alcohol, an amyrin-like compound ($C_{30}H_{50}O$, m.p. 190°), ergosterol, vitamin E and an anti-oxidant ($C_{13}H_{14}O_5$, m.p. 143°). Concentrates of vitamin E and of the anti-oxidant have been prepared. The residual meal left after the extraction of oil contains *c.* 24% protein and is fed to cattle [*Chemurg. Dig.*, 1953, **12**(6-7), 21; *Chem. Abstr.*, 1931, **25,** 5690; 1938, **32,** 3330].

Garden lettuce like other species of *Lactuca* yields lactucarium used as hypnotic in bronchitis and asthma. The latex from the stem and root contains caoutchouc (0.04% and 0.14% respectively). Lettuce is used in poultices for burns and painful ulcers (Nadkarni, I, 720; Kirt. & Basu, II, 1441; *Chem. Abstr.*, 1947, **41,** 4197).

L. serriola Linn. syn. *L. scariola* Linn. PRICKLY LETTUCE

D.E.P., IV, 578; Fl. Br. Ind., III, 404 (in part); Blatter, II, 4, Pl. 34, Fig. 5.

HINDI & BENG.—*Kahu.*

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FIG. 5. LACTUCA SERRIOLA—BEFORE FLOWERING

FIG. 6. LACTUCA SERRIOLA—SEEDS

An erect leafy plant, 60–150 cm. high, usually prickly towards the base, found wild in the western Himalayan region, from Murree to Kunawar, between 1,800 and 3,300 m. Leaves sessile, pinnatifid, prickly beneath on the midrib and nerves; inflorescence similar to that of cultivated lettuce; seeds grey, oblong, *c.* 1.0 cm. long and 1–2 mm. broad.

The plant is valued more for the seeds than leaves. The seeds are used in the form of powder for coughs and as a decoction for insomnia. The ash from the seeds contains fairly good amounts of iron and phosphorus (*Bull. imp. Inst., Lond.*, 1919, **17,** 37; Nadkarni, I, 720; Dhingra & Pershad, *J. Indian chem. Soc.*, 1945, **22,** 127).

The seeds yield 35.2% of a greenish yellow, semi-drying oil with a pleasant odour and sharp taste. It has the following characteristics: sp. gr.$^{21°}$, 0.9230; $n^{21°}$, 1.4880; acid val., 10.2; sap. val., 192.5; iod. val., 121.3; R.M. val., 0.71; Hehner val., 92.1; acet. val., 6.5; and unsapon. matter (contains sitosterol), 2.2%. The fatty acid composition of the oil is as follows: palmitic, 4.0; stearic, 3.74; arachidic, 0.31; oleic, 36.98; and linoleic, 47.05%; caproic acid (2.1%) was reported in one sample of oil. The oil is suitable for use in soap making and in paints and varnishes; it can be used for edible purposes after refining. It is reported to possess hypnotic and antipyretic properties. It is also considered a cure for falling hair (Gambhir & Dutt, *Indian Soap J.*, 1946–47, **12,** 49; Dhingra & Pershad, loc. cit.; *Bull. imp. Inst., Lond.*, 1919, **17,** 37).

The residual meal left after the extraction of oil has a high feed value (total protein, 34.3%; nutritive ratio, 1:1.1) comparable to that of linseed meal. It has a slightly bitter taste and contains traces of an alkaloid (*Bull. imp. Inst., Lond.*, 1919, **17,** 37).

The milky latex from the plant yields lactucarium similar to that from *L. virosa* (q.v.). The latex contains caoutchouc (1.58%), resins (1.85%) and organic acids. The presence of inulin is reported in the roots (Wehmer, II, 1266).

L. indica Linn. syn. *L. brevirostris* Champ., is a tall annual with long, linear-lanceolate leaves and 12–20 flower heads, found in Sikkim Himalayas, Assam and Khasi hills, and extending further into Japan, China and the Philippines. It is cultivated in southern Japan and China, and leaves of selected races are used as vegetable. The leaves are reported to possess tonic, digestive and depurative properties. In Abor hills, the dried latex is used as a substitute for opium. The silk worm is said to feed upon the plant as readily as it does upon mulberry [Burkill, II, 1295; Burkill, *Rec. bot. Surv. India*, 1925, **10**(2), 309].

L. runcinata DC. syn. *L. heyneana* DC. (MAR.—*Undirachakan*), a glabrous herb with radical leaves, is a common weed in many parts of India. The plant is reported to be diuretic, tonic and slightly aperient. It is eaten by cattle and may also have some value as a vegetable. *L. remotiflora* DC. (MAR.—*Undirachakan*; GUJ. *Pathardi*), smaller and more delicate than *L. runcinata*, is found in western U.P., Rajasthan, Saurashtra and the Deccan Peninsula. It is reported to be used for chronic obstructions of liver and bowels, and as diuretic in calculous affections (Kirt. & Basu, II, 1440; Caius, *J. Bombay nat. Hist. Soc.*, 1939-40, **41,** 848; Duthie, I, 490; Koppikar, *Poona agric. Coll. Mag.*, 1950–51, **41,** 290).

L. virosa Linn. (BITTER LETTUCE), a prickly biennial herb with brown tap root and large radical leaves, is a native of Europe. It was formerly cultivated in England, Germany and other European countries; the dried latex of the plant was official under the name Lactucarium. The drug is reported to have been imported to India.

The dried juice of *L. virosa* occurs as small irregular pieces, externally dull reddish or greyish brown, but internally light brown, somewhat porous with a bitter taste and distinct opium-like odour. It is reported to have diuretic, mild sedative and hypnotic properties and has been used in the treatment of dropsy, cough, asthma, gout and jaundice. Its efficacy has, however, been questioned (B.P.C., 1934, 584; U.S.D., 1955, 1732–33; Steinmetz, II, 262).

The drug contains two bitter principles, viz. lactu-

cin ($C_{15}H_{16}O_5$, decomp. 213–17°) and lactucopicrin ($C_{23}H_{22}O_7$, decomp. 148–51°). In addition, it contains *c.* 50% of an odourless and tasteless substance, lactucerin (or lactucon), caoutchouc, and a mydriatic alkaloid (?), similar to hyoscyamine. Lactucerin itself is considered to be a mixture of acetates of α- and β-lactucerol ($C_{30}H_{50}O$, m.p.: α-form, 203° and β-form, 162°); α-lactucerol is identical with taraxasterol (Dolejs *et al.*, *Chem. & Ind.*, 1958, 530; *Chem. Abstr.*, 1954, **48**, 1254; Thorpe, VII, 175).

Lactucarium — *see* **Lactuca**

Lady's Finger — *see* **Hibiscus**

LAGENANDRA Dalz. (*Araceae*)

A small genus of herbs found in south-western India and Ceylon. One species occurs in India.

L. ovata (Linn.) Thw. syn. *L. toxicaria* Dalz.

Fl. Br. Ind., VI, 495.

Mar. *Vatsanabhi;* Tam.—*Maravara tsjembu;* Mal.—*Andavazha, karin-pola.*

Bombay—*Rukh-alu.*

An aquatic herb with a thick, creeping rootstock and large, long-petioled, elliptic-oblong leaves, found in marshes and along water courses throughout the west coast, from Konkan southwards to Kerala and western ghats up to 1,200 m.

The plant is considered poisonous, but the active principle has not been isolated. It contains an acrid juice and is used in ointments for itch. It is reported to have insecticidal properties and tubers are used locally in the treatment of kidney disorders, heart diseases and swellings. The flowers possess a powerful odour by which they attract carrion flies (Chopra, 501; Burkill, II, 1296; Chopra, 1958, 580; Kirt. & Basu, IV, 2602; Rama Rao, 425).

LAGENARIA Ser. (*Cucurbitaceae*)

A monotypic genus found wild in the warmer parts of the Old World and cultivated in India for its fruits used as vegetable.

L. siceraria (Mol.) Standl. syn. *L. leucantha* Rusby; *L. vulgaris* Ser. Bottle Gourd, Calbash Gourd

D.E.P., IV, 580; C.P., 700; Fl. Br. Ind., II, 613.

Hindi—*Kaddu, lauki, tumri;* Beng.—*Lau;* Mar.—*Bhopala, dudhya;* Guj.—*Dudhi, tumada;* Tel.—*Sorrakaya;* Tam.—*Shorakkai;* Kan.—*Halagumbala, sorekayi.*

Assam—*Lau, bogalau;* Punjab—*Ghiya.*

A large pubescent, climbing or trailing herb, with stout 5-angled stems and bifid tendrils, found throughout India, either wild or cultivated. Leaves long-petioled, 5-lobed; flowers large, white, solitary, monoecious or dioecious; fruits large, up to 1.8 m. long, usually bottle or dumb-bell-shaped, almost woody when ripe; seeds numerous, long, white, smooth, 1.6–2.0 cm. long, horizontally compressed with marginal groove.

The cultivated form of *L. siceraria* is considered to be of African or Asian origin; it is found also in America and is supposed to have been introduced in to the New World even before Columbus. The fruits of wild types are characterized by a hard, woody outer layer impervious to water; the pulp is bitter and rather unpalatable, but the shells are used for carrying or holding water; they are also used as floats because of their lightness. As a result of long cultivation, numerous types yielding fruits devoid of woody coat have been evolved. The fruits vary widely in shape and size, and are characterized by soft and sweetish flesh. The cultivated types are given different names, even specific epithets, according to the shape of the fruit, e.g. bottle gourd, long-necked gourd and trumpet gourd. Types differing in their

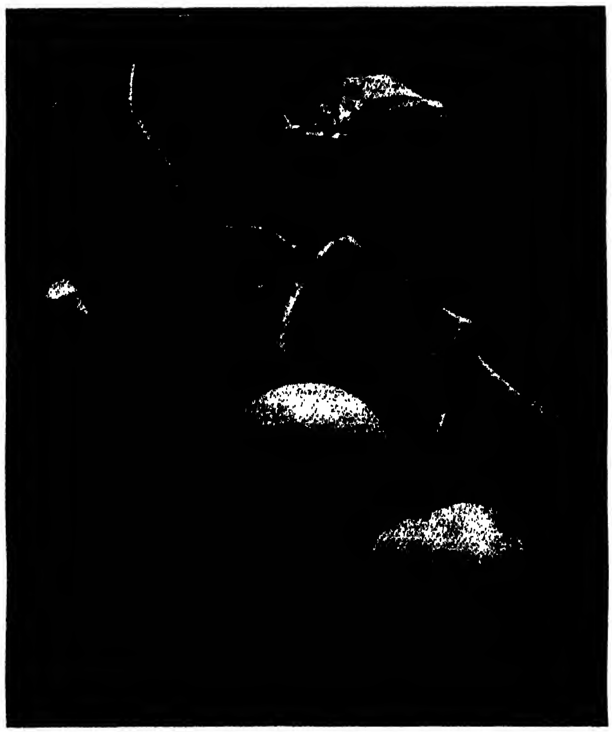

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FIG. 7. LAGENARIA SICERARIA—ROUNDED FRUIT

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FIG. 8. LAGENARIA SICERARIA—BOTTLE-SHAPED FRUIT

adaptation to soil and season are also known. Pusa Summer Prolific is a heavy yielder, suitable for summer as well as rainy season [Burkill, II, 1296; Dalziel, 58; Ames, 86–89; Whitaker & Carter, *Amer. J. Bot.*, 1954, **41,** 697; Camp, ibid., 1954, **41,** 700; Bailey, 1947, II, 1774; Singh & Sikka, *Indian Fmg, N.S.*, 1954-55, **4**(10), 20; Singh *et al.*, *Indian Hort.*, 1956 57, **1**(1), 29].

L. siceraria is a popular vegetable grown almost all the year round, particularly in frost-free areas. It can be cultivated in all kinds of soil, but thrives best in heavily manured loams. It requires a warm humid climate or plenty of watering when grown during dry weather. Seeds may be sown in nursery beds and seedlings transplanted when they have put forth 2–3 leaves. They may be also sown directly, 4–5 seeds together, in manured beds or pits 5–6 ft. apart; the strongest among the seedlings is retained, while others are removed or transplanted. Seedling transplantation is employed where an early crop is desired. Generally two crops are raised in India: the summer crop is sown from the middle of October to the middle of March and the later crop, from the beginning of March to the middle of July. Round fruited types are usually sown for the early crop and long, bottle-shaped types for the second crop. Vines are allowed to trail on the ground or trained over walls, trees, or other support; trailing over the thatch of dwellings is reported to give high yield of fruits (Gollan, 87; Milne *et al.*, 107–08; Roberts & Kartar Singh, 374; Purewal, 73; Singh & Sikka, loc. cit.).

Bottle gourd is susceptible to a number of diseases and pests. Anthracnose, caused by *Colletotrichum lagenarium* (Pass.) Ell. & Halst., appears on young fruits in the form of water-soaked lesions of pinhead size which later become sunken and filled with a spore mass, pinkish at first and black finally. Fruit rot is caused by *Pythium aphanidermatum* (Edson) Fitzpatrick: spongy, water-soaked spots appear on the surface of fruits lying on the ground, which later extend in area, showing white cottony growth of the fungus. Use of thatches 2 ft. high and spraying with Bordeaux mixture (4-4-50) or Cheshunt mixture (1 oz. in 1 gal. of water) are reported to give satisfactory control. *Pseudoperonospora cubensis* (Berk. & Curt.) Rostov. causes downy mildew of leaves, which become yellowish and dry up partially. Early removal of badly infected vines, followed by spraying with 1% Bordeaux mixture prevents spread of the disease. A mosaic disease of leaves has also been reported (Singh & Singh, *Sci. & Cult.*, 1952–53, **18,** 489, 593; Venkatarayan & Venkatakrishniah, *Curr. Sci.*, 1953, **22,** 183; Vasudeva & Lal, *Indian J. agric. Sci.*, 1943, **13,** 182; Capoor & Varma, *Curr. Sci.*, 1948, **17,** 274).

The red pumpkin beetle, *Aulacophora foveicollis* Lucas, is a serious pest of seedlings causing injury to first leaves, sometimes devastating the entire field. Insects may be hand picked to check the spread in small plots and kitchen gardens; dusting with paris green and ashes or with lead arsenate (1:30) is effective in fields; dusting with DDT or gammexane diluted with ashes is also reported to be effective. The fruit fly, of which there are two kinds, damages developing fruits: *Dacus diversus* Coquillett affects

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FIG. 9. LAGENARIA SICERARIA—SEEDS

the yield indirectly by breeding in and destroying male flowers; *D. cucurbitae* Coquillett attacks tender fruits, flowers and even stem forming galls [Singh & Sikka, loc. cit.; Latif & Khan, *Pakist. J. Sci.*, 1952, **4,** 33; Batra, *Indian J. agric. Sci.*, 1953, **23,** 87; Narayanan, *Indian Fmg, N. S.*, 1953–54, **3**(2), 8; **3**(4), 8].

For use as vegetable, bottle gourds are gathered while tender; with increasing maturity the flesh becomes coarse and dry, and seeds become hard. The crop sown in October–March yields fruits from March to July, while the rainy season crop gives fruits in November–December. The fruits are cut with the peduncle and marketed in baskets. Care is required in harvesting and marketing them. If the skin gets injured or scratched, black spots develop in a day or two and the market value is lowered. Injury may be avoided by wrapping fruits in butter paper and transporting them in bamboo baskets lined with neem (*Azadirachta indica*) leaves [Purewal, 74; Singh & Sikka, loc. cit.; Gaitonde & Argade, *Farmer*, 1958, **9**(2), 15].

Each plant yields 10–15 fruits weighing 1–3 lb. each. An average yield of 125–200 md. per acre has been reported (Singh & Sikka, loc. cit.; Milne *et al.*, 108).

Young and tender fruits are eaten as vegetable. The flesh is soft, spongy and insipid when young; it is somewhat bitter when old. Analysis of the edible portion of the fruit gave the following values: moisture, 96.3; protein, 0.2; fat (ether extr.), 0.1; carbohydrates, 2.9; mineral matter, 0.5; calcium, 0.02; and phosphorus, <0.01%. Other mineral elements reported to be present are: iron (0.7 mg./100 g.), sodium (11.0 mg./100 g.), potassium (86.0 mg./100 g.) and iodine (4.5 μg./kg.). Glucose and fructose have been detected. The amino acid composition of the fruit is as follows: leucines, 0.8; phenylalanine, 0.9; valine, 0.3; tyrosine, 0.4; alanine, 0.5; threonine, 0.2; glutamic acid, 0.3; serine, 0.6; aspartic acid, 1.9; cystine, 0.6; cysteine, 0.3; arginine, 0.4; and proline, 0.3 mg./g. (Porterfield, *Econ. Bot.*, 1951, **5,** 3; *Hlth Bull.*, No. 23, 1951, 36; Iodine Content of Foods, 77; Pain & Banerjee, *Indian J. med. Res.*, 1956, **44,** 749; Rao *et al.*, *J. sci. industr. Res.*, 1956, **15C,** 39; Majumder *et al.*, *Food Res.*, 1956, **21,** 477).

The fruit is a good source of B vitamins and a fair source of ascorbic acid. The edible portion contains: thiamine, 44 μg.; riboflavin, 23 μg.; niacin, 0.33 mg.; and ascorbic acid, 13.0 mg./100 g.; it contains 16.02 mg./g. (dry basis) of choline (Porterfield, loc. cit.; Intengan *et al.*, *Philipp. J. Sci.*, 1953, **82,** 247; Ahmad *et al.*, *Indian J. med. Res.*, 1953, **41,** 441).

The fruit is rich in pectin (21%, on dry wt.). The pectin has the following composition: uronic anhydride, 58.48; furfural, 20.72; and methoxyl val., 5.39%. The jelly prepared from gourd pectin possesses good strength properties (Krishnamurti & Giri, *Proc. Indian Acad. Sci.*, 1949, **29B,** 155).

Bitter fruits yield 0.013% of a solid foam containing cucurbitacins B, D, G and H, mainly cucurbitacin B ($C_{32}H_{48}O_8$, m.p. 184–86°); these bitter principles are present in the fruit as aglycones. Leaves contain cucurbitacin B, and roots, cucurbitacins B, D and traces of E. The fruit juice contains β-glycosidase (elaterase), opt. pH in phosphate buffer, 4.0–5.5; opt. temp., 50°. Plants which yield non-bitter fruits contain no bitter principles or elaterase; the roots of such plants are not bitter (Enslin, *J. Sci. Fd Agric.*, 1954, **5,** 410; Enslin *et al.*, ibid., 1956, **7,** 646; 1957, **8,** 673; Rehm *et al.*, ibid., 1957, **8,** 679).

The seeds (wt. of 100 seeds, 15 g.) are edible. In China, they are boiled in salt water and eaten as an appetiser. Analysis of seed kernels (68% of seed wt.) from Sudan gave the following values: moisture, 2.47; protein, 30.72; oil, 52.54; carbohydrates, 8.3; fibre, 1.58; ash, 4.43; CaO, 0.11; and P_2O_5, 2.46%. Seeds are reported to contain a saponin (Porterfield, loc. cit.; Grindley, *J. Sci. Fd Agric.*, 1950, **1,** 152; Wehmer, II, 1203).

The oil obtained from seed kernels is clear and pale yellow. It is used in parts of Africa for edible purposes. Kernels from ripe seeds (40% of seed wt.) from Bengal gave 45% of oil with the following characteristics: $n_D^{40°}$, 1.4711; sap. equiv., 301.6; iod. val., 126.5; free fatty acids (as oleic), 0.54%; and unsapon. matter, 0.67%. The component fatty acids of the oil are: linoleic, 64.0; oleic, 18.2; and saturated acids, 17.8%. The oil from seeds collected from U.P. had a lower linoleic acid content (29.84%) with correspondingly higher saturated acids. The cake left after the extraction of oil from decorticated seeds is rich in protein and may be used as cattle feed (Dalziel, 59; Grindley, loc. cit.; Chowdhury *et al.*, *Sci. & Cult.*, 1953–54, **19,** 163; *Chem. Abstr.*, 1936, **30,** 3673).

The plant is often cultivated for the fruit shell used as water bottles and bowls; ladles, pipes, blowing horns, snuff boxes, etc. are also made from the shell. The shapes of fruits may be manipulated as desired when the fruits are young; dry shells are used in musical instruments like *sitar* and *bin*

(Dalziel, 59–60; Burkill, II, 1297; Porterfield, loc. cit.).

Tender shoots and leaves are consumed as vegetable in India. The amino acid composition of the edible material (moisture, 90.8; protein, 2.5%) is as follows: leucines, 2.3; phenylalanine, 1.0; valine, 1.0; tyrosine, 0.4; alanine, 1.1; threonine, 0.8; glutamic acid, 1.7; serine, 0.9; aspartic acid, 2.9; cystine, 1.7; cysteine, 0.4; lysine, 5.2; methionine sulphoxide, 0.3; and proline, 0.3 mg./g.; the vitamin C content of leaves is reported to vary according to locality; samples from Bengal, Bihar and Assam contained respectively 5.0, 33.0 and 8.5 mg./100 g. The presence of steroidal sapogenins in leaves (0.13% on dry wt.) has been reported from Philippines (Majumder *et al.*, *Food Res.*, 1956, **21,** 477; Barua, *J. Indian chem. Soc.*, 1946, **23,** 238; Anzaldo *et al.*, *Philipp. J. Sci.*, 1957, **86,** 233).

The fruit pulp around the seeds is considered emetic as well as purgative; it is given to horses. It is cooling, diuretic and antibilious and applied externally in delirium. A syrup prepared from the tender fruit is used as pectoral. The juice of the fruit mixed with lime juice is used as an application for pimples; boiled in oil it is used for rheumatism; the leaf juice is used for baldness (Chopra *et al.*, 491; Kirt. & Basu, II, 1117; Burkill, II, 1297–98; Quisumbing, 939).

The seeds are used in dropsy and as anthelmintic; the root is also used in the treatment of dropsy. The seed oil is applied externally in headaches. The prickly cortex of the vine and flowers are regarded as counter poisons (Kirt. & Basu, II, 1117–18; U.S.D., 1947, 1469; Porterfield, loc. cit.).

LAGERSTROEMIA Linn. (*Lythraceae*)

A genus of trees and shrubs distributed chiefly from South-East Asia to Australia. Some species yield valuable timbers; a few are ornamental. About 10 species occur in India.

L. hypoleuca Kurz

D.E.P., IV, 582; Fl. Br. Ind., II, 577.

ANDAMANS—*Pabda, pyinma.*

TRADE—*Andaman pyinma.*

A large tree, 18–21 m. in height and 3 m. in girth, with a clean bole of *c.* 7.5 m., found in deciduous and evergreen forests in Andaman Islands. Bark thin, white; leaves ovate to ovate-lanceolate, 15–20 cm. long; flowers in long terminal panicles, lilac; capsules ovoid, 1.6 cm. long, woody.

The tree is usually found on low ground and sandy soil and is less common on hills. It seeds freely almost every year and natural reproduction is reported to be good. The rate of growth is slow (10–18 rings/in. radius). The tree is suitable for cultivation in wet low-lying lands of Bengal (Troup, II, 604–05; Gamble, 375; Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 81).

The wood is hard, very strong, elastic and heavy (sp. gr., *c.* 0.66; wt., 38–44 lb./cu. ft.). It is somewhat similar in appearance to teak but rather light in colour. It is easy to air-season but end-splits are likely to develop if left in the log; green conversion with open stacking of sawn material is recommended. The shrinkage during seasoning is considerable and the wood swells up when wet. The timber takes 12–15 days for kiln-seasoning; in addition to initial steaming, it needs at least one intermediate steaming and one steaming towards the end of drying at 55° & 100% R.H. for 2–4 hours. During precision drying for high class work, e.g. railway carriage building, conditioning treatment should be given (Pearson & Brown, II, 590, 592; Trotter, 1944, 125–26; *Descriptive List of some Empire Timbers*, Imp. Inst., Lond., 1928, 22; Rehman, *Indian For.*, 1953, **79,** 369).

The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 90; strength as a beam, 80; stiffness as a beam, 80; suitability as a post, 75; shock-resisting ability, 85; retention of shape, 70; shear, 100; and hardness, 80. The timber is a moderately good bender with a tendency for the bend to open. It is seldom attacked by white ants and is moderately durable (durability as determined by graveyard tests, 7–10 years) (Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** Sheet No. 12; Rehman *et al.*, *Indian For.*, 1956, **82,** 469; Purushotham *et al.*, ibid., 1953, **79,** 49; Pearson & Brown, II, 592).

The timber is used for building purposes, such as planking, scantlings, shingles, floor boards, door and window frames and interior work. It is a good furniture wood. It is used for electric and telephone poles and also for electric fittings, cooperage, golf stick shafts, spokes and felloes of wheels, etc. It is especially suitable for boat and ship building, and for piles, being resistant to marine borers. It is also suitable for plywood and, occasionally, highly figured beautiful panels are available. The timber of this species has been sometimes sold in Calcutta market as *L. speciosa*

For., 1952, **78**, 270 ; *Descriptive List of some Empire Timbers*, Imp. Inst., Lond., 1928, 22 ; *Industry, Calcutta*, 1950, **41**, 299 ; Gamble, 375).

L. indica Linn. COMMON CRAPE MYRTLE

D.E.P., IV, 583 ; Fl. Br. Ind., II, 575.

HINDI & BENG.—*Pharash, telingachina ;* TEL.—*Chinagoranta ;* TAM.—*Pavalak-kurinji, sinappu.*

PUNJAB—*Saoni, dhaura ;* BOMBAY—*Chinai-mendhi.*

A handsome deciduous shrub or a small tree, native of China, commonly cultivated in gardens throughout India for its beautiful flowers. Though usually a shrub under cultivation, it is reported to attain a height of 15 m. in Assam forests, where it is possibly wild. Bark smooth, ashy or nearly white, peeling off in thin pieces ; leaves elliptic or obovate ; flowers in terminal panicles, white, rose or mauve ; capsules globose ; seeds winged.

The wood (wt., 42 lb./cu. ft.) is white or brownish and hard ; charcoal made from it is used for thickening lacquer in Japan. The Atlas silk-worm moth feeds on the plant (Gamble, 371 ; Burkill, II, 1299).

The bark of *L. indica* is considered stimulant and febrifuge. Bark, leaves and flowers are said to be used in Indo-China as purgative and hydragogue. The roots are astringent and used as gargle. The seeds contain a narcotic principle (Kirt. & Basu, II, 1082 ; Quisumbing, 640 ; Chopra, 1958, 546).

L. lanceolata Wall.

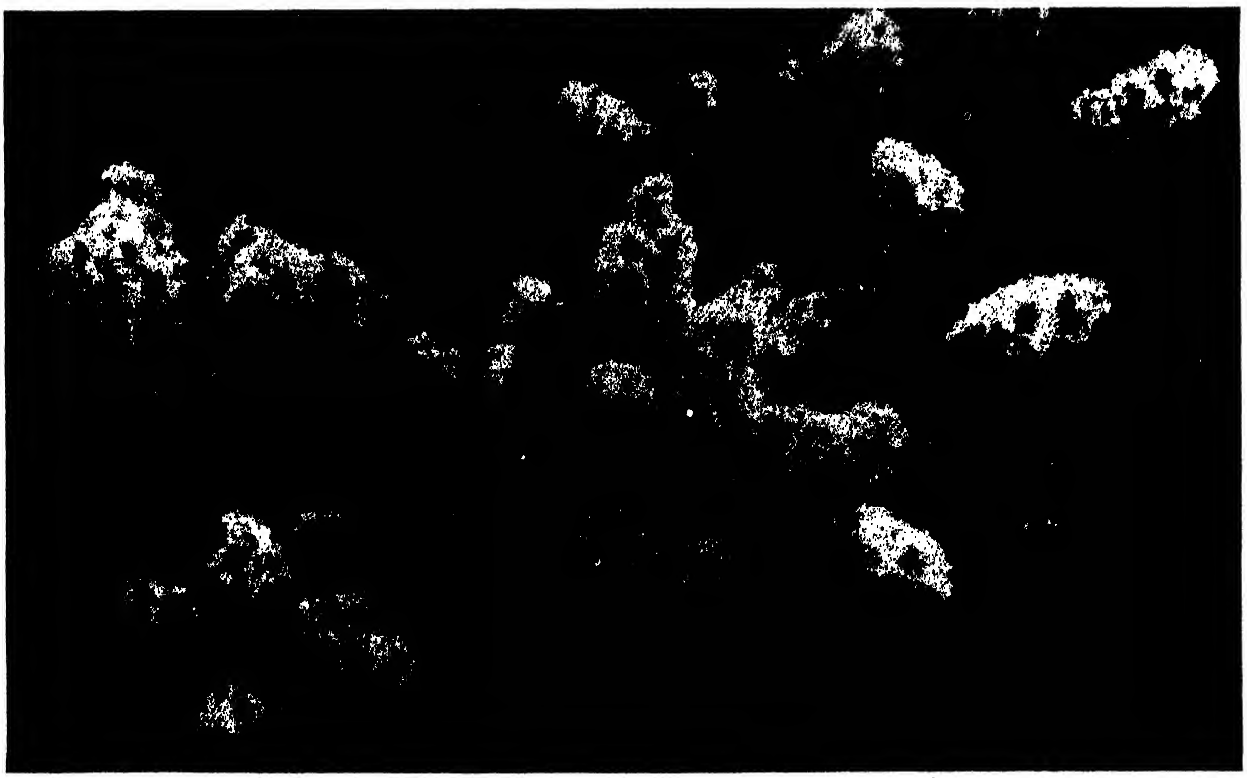
D.E.P., IV, 583 ; Fl. Br. Ind., II, 576.

MAR.—*Nana ;* TEL.—*Ventaku ;* TAM.—*Vevala ;* KAN.—*Benteak, bili-nandi, bolundur ;* MAL.—*Velillavu, venthekku.*

BOMBAY—*Bondara, bodaga, sukutya ;* TRAVANCORE HILLS—*Venda, vengalam.*

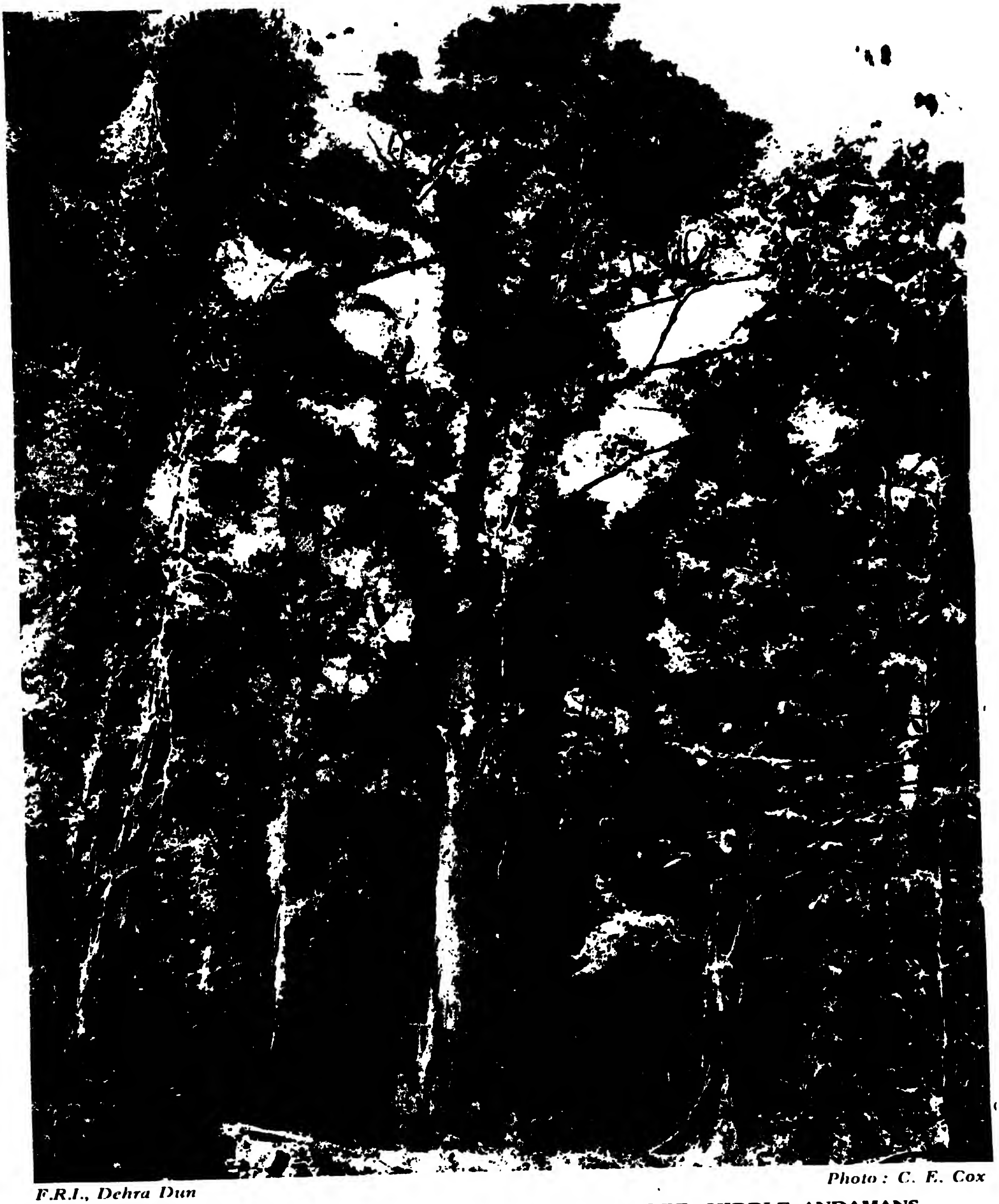
TRADE—*Benteak, nana.*

A moderate-sized to large deciduous tree, sometimes attaining 30 m. in height and 2.4–3.0 m. in girth, with a clean cylindrical bole of 12–15 m. It is found from Bombay southwards to Kerala and in the hills of Deccan Peninsula up to an altitude of 1,200 m. Bark smooth, greenish or yellowish white, exfoliating in papery strips ; leaves elliptic-lanceolate or broadly ovate, 6.2–10.0 cm. x 1.8–5.0 cm., coriaceous, glabrous, shining above, usually white or greyish blue, hoary-



F.R.I., Dehra Dun. Photo : H. G. Champion

FIG. 10. LAGERSTROEMIA INDICA—IN FLOWER



F.R.I., Dehra Dun

Photo : C. F. Cox

LAGERSTROEMIA HYPOLEUCA — WELL GROWN TREE, MIDDLE ANDAMANS

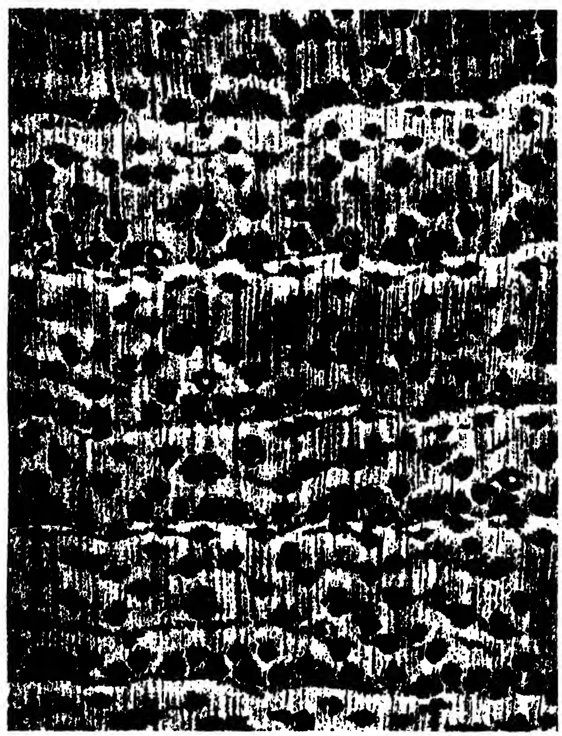
FIG. 11. LAGERSTROEMIA LANCEOLATA—FLOWERING BRANCH

tomentose beneath; flowers small, white, in large compound panicles; capsules ellipsoid; seeds winged.

The tree grows well on hill slopes and in valleys preferring crystalline rock to laterite. It is usually found in mixed deciduous forests, but isolated specimens also occur in evergreen forests. It attains its best development in regions of heavy rainfall, e.g. in Kanara, Malabar and Coorg. Natural reproduction takes place by seeds which fall early in the hot season and germinate at the beginning of rains; the seeds are light and are carried by winds to some distance from the tree and germination appears to be uncertain. Seedlings do not stand exposure to sun and benefit by slight shade. Bare loose soil aids natural reproduction which appears freely on abandoned cultivation. Limited grazing helps to suppress undergrowth and favour natural reproduction. The growth is moderately fast (6–8 rings/in. radius), the mean annual girth increment being 0.78–1.05 in. The tree coppices well; coppice shoots attain a height of 39 ft. and diam. of 9.75 inch in 40 years. The tree is susceptible to attack by white spongy rot (*Daedalea flavida* Lev.), white stump rot (*Fomes durissimus* Lloyd) and tar spot (*Rhytisma lagerstroemiae* Rabenh.) (Troup, II, 602–04; Gamble, 373; *Indian J. agric. Sci.*, 1950, **20**, 107). 45,907

Benteak wood is strong, elastic and heavy (sp. gr., *c.* 0.7; wt., 42 lb./cu. ft.). It is difficult to season and is liable to end-splits and warps. Logs should be protected from sun and hot winds. Good results are obtained by felling trees ten months after girdling and storing sawn stock for 18 months. It is likely that logs converted in the green and immersed in water for 4–6 months, followed by stacking and drying, yield better results. The timber can be kiln-seasoned in 12–15 days; it is easy to season as planks 1.0 in. thick; thicker planks are liable to surface cracking. A little warping, cupping and twisting may also be noticed around knots. In addition to initial steaming, the timber needs at least one intermediate steaming and one steaming towards the end of drying at 55° & 100% R.H. for 2–4 hours.

The timber is durable in exposed situations as well as under cover and in contact with water. Graveyard tests gave a durability of 10 years or more. It is moderately resistant to white ants and is not prone to fungus attack. It is difficult to treat even under pressure; sleepers take up only 2–3 lb./cu. ft. of preservative.



F.R.I., Dehra Dun. Photo: S. S. Ghosh

FIG. 12. LAGERSTROEMIA LANCEOLATA—TRANSVERSE SECTION OF WOOD (×10)

MISSION
URE

The wood can be sawn and worked by machine or by hand ; it finishes to a smooth surface and takes a fair polish. Timber from well-grown trees has fine straight grain with few or no knots. Burrs occasionally form at the base and up the bole and these, when opened out, sometimes yield fine figure. The data for comparative suitability of timber, expressed as percentages of the same properties of teak, are: wt., 100 ; strength as a beam, 90 ; stiffness as a beam, 100 : suitability as a post, 90 ; shock-resisting ability, 105 ; retention of shape, 65 ; shear, 105 ; and hardness, 105 (Pearson & Brown, II, 582-83 ; Purushotham *et al., Indian For.*, 1953, **79,** 49 ; Trotter, 1944, 127 ; Rehman. *Indian For. Bull., N.S.*, No. 198, 1956, 4 ; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** Sheet No. 12).

Benteak is chiefly used for building construction, bridges, ships and boats. It is also used for railway carriages, wagons, motor lorry and bus bodies, and hand barrows. It is suitable for commercial plywood, match boxes and splints, trestle stands and shooting sticks of spring-back type. It is used for furniture, boxes, grinding mills, agricultural implements, carts, spokes and felloes, and general carpentry purposes, golf stick shafts and picker arms, and appears promising for badminton and tennis rackets. It is useful for turney, cooperage and bent-wood work and has been recommended for electric transmission poles and railway sleepers (Pearson & Brown, II, 583 ; Trotter, 1944, 127–28, 207 ; Chowdhury, *Indian For. Leafl.*, No. 37, 1943, 17 ; *Indian For.*, 1952, **78,** 276, 278 ; Dastur, Useful Plants, 134 ; Rehman *et al., Indian For.*, 1956, **82,** 469 ; Gupta, loc. cit. ; Narayanamurti, *Indian For. Bull., N.S.*, No. 140, 1948, 2 ; Rama Rao, 180).

Benteak is a good fuel wood (calorific value: *sapwood* 4,956 cal., 8,921 B.t.u. ; *heartwood*—5,078 cal., 9,141 B.t.u.). Carbonization gave (dry basis): charcoal, 33.1 ; pyroligneous acid, 36.6 ; acid, 4.19 ; esters, 3.42 ; acetone, 1.99 ; methanol, 1.36 ; tar, 7.5 ; pitch & losses, 2.9% (Rodger, *Indian For. Bull.*, No. 19, 1913 ; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 19 ; Kedare & Tendolkar, *J. sci. industr. Res.*, 1953, **12B,** 217).

The leaves of *L. lanceolata* (N, 1.05%) are used as green manure in arecanut gardens. Tannin is present in leaves (8.2%), bark (0.31%) and fruit [Sonde, *Arecan. Bull.*, 1955–56, **6,** 77 ; Edwards *et al., Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 158 ; Rodger, loc. cit.].

L. parviflora Roxb.

D.E.P., IV, 583 ; C.P., 701 ; Fl. Br. Ind., II, 575.

HINDI—*Dhaura, lendia, bakli, sidi* ; BENG.—*Sida* ; MAR.—*Lende, bondga, bondara* ; GUJ.—*Kakria* ; TEL.—*Chinangi* ; TAM.—*Chenangi* ; KAN.—*Channangi, ventaku* ; MAL.—*Cimanii, ventekku* ; ORIYA—*Salora.*

PUNJAB—*Bakli, dhaura* ; NEPAL—*Bhot duanyaro, borderi* ; LEPCHA—*Kunhil-kung* ; ASSAM—*Sida, dhauli* ; HYDERABAD—*Chungi.*

TRADE—*Lendia.*

A medium-sized deciduous tree, 15–18 m. in height and 1.5–1.8 m. in girth, with a clean bole of 3.6–4.5 m., found almost throughout India up to an altitude of 900 m. in the Himalayas. Bark light grey to reddish, smooth, exfoliating in narrow longitudinal flakes ; leaves elliptic, oblong or ovate, 5–10 cm. × 2.5–3.7 cm., glabrous, shining above, greyish and more or less

F.R.I., Dehra Dun. Photo : K. P. Sagreiya

FIG. 13. LAGERSTROEMIA PARVIFLORA—COPPICE CLUMPS

pubescent beneath; flowers in lax axillary and terminal panicles, white, fragrant; capsules ovoid or ellipsoid; seeds winged.

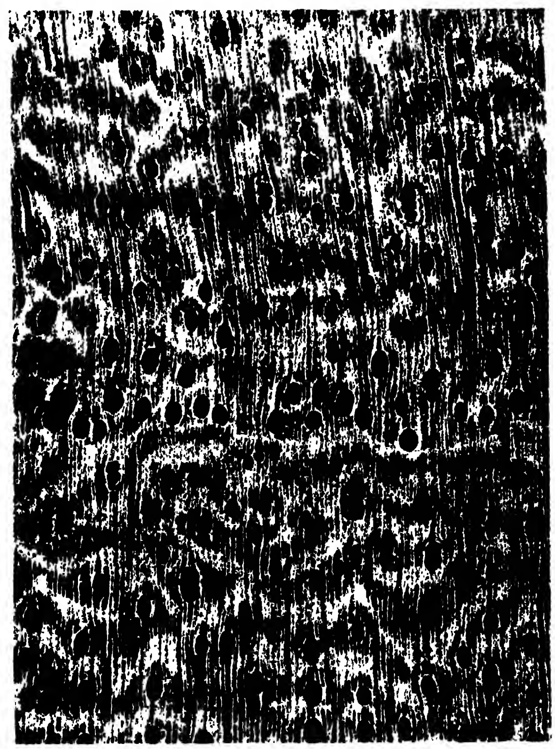
The tree is generally found in dry mixed forests and though often plentiful, it is not gregarious. It is often found as a companion of sal, teak and other commercial species. The tree grows in a variety of soils and geological formations, including black cotton and trap; it thrives best on deep porous loam and though often found on clay, it does not stand water-logging. It is a light-demander and fairly frost-hardy.

Natural reproduction takes place by seeds. Fertile seeds are not produced in abundance every year. Loose, porous, bare soil appears to favour natural reproduction. Immunity from damage by grazing and good power of recovery from the effects of fire and mutilation are factors which favour natural reproduction. The rate of growth is moderately fast, mean annual girth increment being *c.* 0.96 in. The tree coppices and pollards vigorously and is eminently adapted for working as coppice, a rotation of 30 years being generally sufficient for the production of poles for building purposes. The tree is subject to the attack of white stump rot (*Fomes durissimus* Lloyd), dark brown heart rot (*Fomes fastuosus* Lev.), white spongy rot (*Fomes pectinatus* Kl.), spongy yellow heart rot (*Fomes rimosus* Berk.), white pocket rot [*Polyporus gilvus* (Schw.) Fr.], tar spot (*Rhytisma lagerstroemiae* Rabenh.) and grey heart rot [*Trametes incerta* (Currey) Ckc.] (Troup, II, 593–97; Benskin, *Indian For. Bull.*, No. 28, 1915; *Indian J. agric. Sci.*, 1950, **20,** 107).

Lendia wood is strong, hard and heavy (sp. gr., *c.* 0.75; wt., 46–48 lb./cu. ft.). It is difficult to air-season as it is prone to end-splitting, surface cracking and warping. It should be converted green, preferably in damp or cool weather and piled under cover, well protected from hot winds and sun, and allowed to dry slowly. At least 2 years should be allowed for drying stock 2 in. thick. End-coating of scantlings or planks minimizes end-splitting. In dry hot localities, the only method of air-seasoning the timber is either to girdle the trees for a year and then fell and convert, or convert green logs and immerse the stock in water for 2–3 months, followed by fairly close stacking of material in a well-protected shed. Kiln-seasoning presents no difficulties (Pearson & Brown, II, 578; Trotter, 1944, 129).

The wood is only fairly durable (av. life as determined by graveyard tests, 4–5 years). It is liable to white ant and insect attacks. The wood can be treated with preservatives but penetration into heartwood is poor; absorption in sleeper-treating trials varied from 2 to 10 lb./cu. ft. and was patchy. The timber is not difficult to saw and work, especially when green. It machines well and finishes to a shiny smooth surface which takes a good polish. Sometimes it exhibits a short wavy grain. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 105; strength as a beam, 90; stiffness as a beam, 100; suitability as a post, 90; shock-resisting ability, 120; retention of shape, 60; shear, 135; and hardness, 110 (Pearson & Brown, II, 579; Trotter, 1944, 129; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** Sheet No. 12).

Lendia is used for building construction, fencing, bridges, boats, oars and agricultural implements; also for carts, cooperage, wood pipes and water tanks. It is suitable for boxes, tool handles, tent pegs, wedges for ship's hatches, golf stick shafts, leather cutting blocks, bent-wood furniture, picker arms and telegraph poles. Selected timber with figured grain should make decorative furniture. It is recommended for rail-



F.R.I., Dehra Dun. Photo: S. S. Ghosh

FIG. 14. LAGERSTROEMIA PARVIFLORA—TRANSVERSE SECTION OF WOOD (×10)

way sleepers after treatment (Pearson & Brown, II, 579; Dastur, Useful Plants, 135; Trotter, 1944, 130; Rehman & Askari, *Indian For. Bull., N.S.*, No. 200, 1956, 2; Gupta, loc. cit.).

Charcoal made from lendia wood may prove suitable for producer gas. The calorific value of wood is: *sapwood* -4,951 cal., 8,913 B.t.u.; *heartwood*—4,885 cal., 8,794 B.t.u. Carbonization trials yielded (dry basis): charcoal, 36.2; pyroligneous acid, 35.8; acid, 4.67; esters, 3.98; acetone, 2.48; methanol, 0.82; tar, 8.7; pitch & losses, 2.1%. Analysis of wood ash (2.16%, dry basis) gave: $Fe_2O_3+Al_2O_3$, 0.35; CaO, 56.14; MgO, 6.40; K_2O, 7.18; Na_2O, 10.16; SO_3, 3.22; Cl, 0.22; and P_2O_5, 1.65% (Ramaswami, *Indian For. Leafl.*, No. 9, 1942, 3; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 19; Kedare & Tendolkar, *J. sci. industr. Res.*, 1953, **12B**, 217).

The bark and leaves of *L. parviflora* contain tannin (7-10% and 16% respectively); tanning trials showed that a good fawn colour is produced on light leather. The bark is reported to be used for dyeing thread. It yields an inferior fibre. The tree is lopped for fodder and is a host of the tussur silk worm; it is reported to yield a sweet edible gum (Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 158; Benskin, loc. cit.; Laurie, *Indian For. Leafl.*, No. 82, 1945, 9).

L. speciosa Pers. syn. *L. flos-reginae* Retz.; C.B. Clarke (Fl. Br. Ind.) in part QUEEN CRAPE MYRTLE
D.E.P., IV, 582; C.P., 701; Fl. Br. Ind., II, 577.

HINDI *Jarul*; BENG.—*Jarool, ajar*; MAR. *Taman, mota-bondara*; TEL.—*Varagogu*; TAM. -*Kadali, pumaruthu*; KAN. *Hole-dasavala, challa*; MAL.—*Manimaruthu*; ORIYA—*Patoli*.

PUNJAB—*Jarul*; ASSAM—*Ajar, thing-dou thlado*.

TRADE—*Jarul, pyinma*.

A medium-sized to large deciduous tree with a rounded crown, distributed more or less throughout India, especially in Assam, Bengal and Deccan Peninsula. Bark smooth, greyish, exfoliating in irregular flakes; leaves oblong-lanceolate or ellpitic; flowers in large panicles, mauve to purple; capsule ellipsoid or sub-globose; seeds pale brown.

Jarul is one of the well-known ornamental trees and is widely cultivated in gardens and as an avenue tree. In favourable situations it attains a height of 24 m. and girth 3.6 m. with a clean bole of 12 m.; it is usually much smaller. It grows best on rich deep alluvial loam and it is typically found along banks of rivers and streams and in low-lying swampy areas, though it is not always confined to such places. The tree is a moderate light-demander and becomes suppressed under heavy shade.

Natural reproduction takes place by seeds which germinate early in the rainy season. Seedlings are reported to develop well in bare loose soil under exposure to light. Drought and weed growth are unfavourable. Artificial regeneration is possible by raising seedlings in a nursery and transplanting them in the field. The growth rate is moderately fast (7 rings/in. radius). The tree coppices well and the shoots grow vigorously (Troup, II, 598-600; Gamble, 373).

Jarul wood is hard, strong, elastic and moderately heavy (sp. gr., c. 0.54; wt., 39 lb./cu. ft.). It air-seasons without difficulty; best results are obtained by converting logs green or felling 1–2 years after girdling, followed by open stacking. The wood is liable to crack and split if left in the log, and it reabsorbs moisture even after long seasoning. Kiln-seasoning takes 16-20 days; in addition to initial steaming, it needs two intermediate steamings before the final steaming at 55° & 100% R.H. for 2–4 hours (Pearson & Brown, II, 587–89; Rehman, *Indian For. Bull., N.S.*, No. 198, 1956, 4).

The timber is moderately durable in the open and durable under cover and in contact with water (av. life, 7–10 years). It is liable to insect attack, but is moderately resistant to white ants. The timber is difficult to treat and does not absorb more than 2 lb./cu. ft. of preservative. It saws, works and machines well and finishes to a smooth surface taking a good lasting polish. Timber with broad wavy grain and handsome in appearance is occasionally met with. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 95; strength as a beam, 80; stiffness as a beam, 85; suitability as a post, 75; shock-resisting ability, 85; retention of shape, 65; shear, 100; and hardness, 105 [Pearson & Brown, II, 589; Purushotham *et al.*, loc. cit.; Chowdhury, *Indian For. Rec., N.S., Util.*, 1951, **1**(3), 29; Trotter, 1944, 125; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, Sheet No. 12].

Jarul is a constructional timber of considerable commercial importance, particularly in North-East India. It is used for building purposes, planking, ship building, piles, bridges, water tanks, well curbs, boats, dug-outs and oars, railway carriages, motor lorry bodies, floor boards, rice pounders, mortars, turnery, cooperage and as mine props. It is used to a limited

extent for furniture, carts, spokes of wheels, shafts, ploughs and boxes. It is suitable for telegraph poles, leather cutting blocks, boot lasts, match boxes and splints. It has been used for gun carriages and is suitable for country made guns and rifles. It is recommended for railway sleepers after suitable treatment. It has been used for flood-traps in the Philippines (Pearson & Brown, II, 589–90; Gamble, 374; Dastur, Useful Plants, 136; Rodger, 128–29; Trotter, 1944, 126; Chowdhury, *Indian For. Leafl.*, No. 37, 1943, 17; Gupta, loc. cit.; *Industry, Calcutta*, 1950, **41**, 299; Rama Rao, 180; Fox, *Philipp. J. Sci.*, 1952, **81**, 285.

The leaves of *L. speciosa* are purgative, deobstruent and diuretic. A decoction of the leaves, also of dried fruit, prepared like tea, is used for diabetes mellitus in Philippines. Several parts of the plant contain an amorphous, slightly bitter insulin-like principle, with a hypoglycemic activity of 440 insulin units/g. when administered orally to rabbits and twice that strength when given subcutaneously. The maximum concentration of the principles is found in mature leaves and fruits in the fresh condition; the potency decreases on storing the material. The bark is considered stimulant and febrifuge and a decoction or infusion is given in abdominal pain and diarrhoea. The roots are considered astringent, stimulant and febrifuge and seeds are narcotic. Roots, stems and leaves contain hydrocyanic acid (Kirt. & Basu, II, 1081; Quisumbing, 641–42; Garcia, *Philipp. J. Sci.*, 1944, **76**, 3; Burkill, II, 1300).

F.R.I., Dehra Dun. Photo: C. E. Parkinson

FIG. 15. LAGERSTROEMIA SPECIOSA—FLOWERING BRANCH

The leaves, fruits and bark contain tannin (12.8–13.3, 14.3–17.3 and 10% respectively). Leaves and fruits may be used for the preparation of tannin extract. A coarse fibre is obtained from the inner bark. The tree exudes a resin (Pilgrim & Pasupati, *Indian For.*, 1923, **49**, 158; Quisumbing, 640; Cameron, 150).

LAGGERA Sch.-Bip. ex Hochst. (*Compositae*)

D.E.P., IV, 584; Fl. Br. Ind., III, 270; Fyson, II, Pl. 269.

A small genus of annual or perennial herbs distributed throughout tropical Africa, Madagascar and Asia. Four species are recorded in India.

L. alata Sch.-Bip. ex Oliver is a stout, much-branched, leafy perennial, 0.6–1.8 m. high, with sessile, narrowly oblong or oblong-lanceolate leaves and minute, purplish or pink flowers, found almost throughout India, ascending up to 2,100 m. in the hills. The plant is used in Madagascar as a disinfectant. Tender leaves appearing after the first rains have the odour of black currant and are reported to yield an ethereal oil (Caius, *J. Bombay nat. Hist. Soc.*, 1939–40, **41**, 849; Fyson, I, 326; *Chem. Abstr.*, 1943, **37**, 6410).

L. aurita Sch.-Bip. ex C.B. Clarke (MUNDARI—*Soan puru*) is a slender, viscidly hirsute or villous herb, 0.3–0.9 m. high, with sessile or petioled, oblanceolate, deeply lobed or pinnatifid leaves and small, pink or purplish flowers, found in waste places from Punjab eastwards to West Bengal, Orissa, Andhra, Madras, Kerala and Bombay. The plant is strongly scented and possesses the odour of turpentine. The leaves are reported to be used by Mundas to stop bleeding from cuts (Bressers, 82).

LALLEMANTIA Fisch. & Mey. (*Labiatae*)

A very small genus of annual or biennial herbs distributed from India to western Asia. One species is recorded in India.

L. royleana Benth.

D.E.P., IV, 585; Fl. Br. Ind., IV, 667; Mukerjee, *Rec. bot. Surv. India*, 1940, **14** (1), 139; Kirt. & Basu, Pl. 766C.

An erect, hoary-pubescent or glabrate annual, 15–45 cm. high, found in the plains and hills of Punjab and Kumaon up to 900 m., extending westwards to Afghanistan, Persia and Turkestan. Leaves ovate or oblong, 2–5 cm. long, obtuse, coarsely crenate; flowers small, pale lilac, in numerous whorls in long interrupted spikes; nutlets 2.5 mm. long, narrowly oblong, black and smooth.

L. royleana is cultivated for its mucilaginous seeds. It requires rich, loamy, well-drained soil and frequent irrigation. It responds well to cultivation and is grown, to a small extent, in Ropar (Punjab). Seeds are sown in September-October at the rate of 3–4 lb. per acre and the crop is harvested in April; a yield of 4–5 md. of seeds per acre has been recorded (Luthra, *Indian Fmg*, 1950, **11,** 10; Khan, *Pakist. J. For.*, 1957, **7**, 319).

The seeds (Hindi—*Gharei kashmalu, tukhmle-alanga;* Bombay *Tukhm-i-balangu;* Punjab—*Tukhm-malanga, gharei kashmalu*) are said to be imported from Persia and are available with Indian drug sellers. They are also offered as black psyllium seed and a substitute for ispaghula (from *Plantago* sp.). When moistened, the seeds become coated with a translucent, tasteless mucilage. They are, however, considered dangerous for internal use as, when ingested, the mucliage forms rigid peltate masses which by interlocking with intestinal contents tend to occlude the lumen of the bowel (Dymock, Warden & Hooper, III, 90; Luthra, loc. cit.; Youngken, 811; U.S.D., 1955, 1071).

The seeds are valued for their cooling, sedative and diuretic properties and are used in the preparation of beverages. They are given internally as soothing drink in urinary troubles. In Persia, they are recommended for cough. A poultice of the seeds is applied to abscesses, boils and inflammations (Kirt. & Basu, III, 2006; Chopra, 1958, 677; Caius, *J. Bombay nat. Hist. Soc.*, 1940-41, **42,** 392; Kanny Lall Dey, 173).

The seeds yield 10.8% of a light green, semi-drying oil with the following characteristics: sp. gr.$^{32°}$, 0.9162; $n^{30°}$, 1.4212; sap. val., 191.20; iod. val., 108.5; acid val., 2.07; Hehner val., 89.3; and unsapon. matter (sitosterol), 0.28%. The mixed fatty acids contain: stearic, 3.2; palmitic, 10.1; oleic, 59.4; and linolenic, 26.1% (Malavya & Dutt, *Proc. Indian Acad. Sci.*, 1941, **14A,** 80).

Lamb's Quarters — *see* **Chenopodium**

Laminaria — *see* **Algae**

LAMIUM Linn. (*Labiatae*)

A genus of annual or perennial herbs distributed in Europe, North Africa and temperate Asia. Three species occur in India.

L. album Linn. White Deadnettle

Fl. Br. Ind., IV, 679; Mukerjee, *Rec. bot. Surv. India*, 1940, **14** (1), 161.

An ascending or decumbent, glabrous or hispidly hairy perennial herb, 25–50 cm. high, with a creeping rootstock, found in waste places and along road sides in western Himalayas from Kashmir to Kumaon at altitudes of 1,500–3,000 m. Leaves ovate-cordate, crenate or serrate; flowers white or pale pink, in axillary whorls; nutlets *c.* 4 mm. long, smooth, black or dark brown.

The plant possesses astringent properties and is reported to be used in decoction against haemorrhages of the uterus, nose, etc. It contains mucilage, tannin, invert sugar, a glycoside, a saponin and potassium salts; it also yields an essential oil (0.0045%) containing 4.4% phenol (Steinmetz, II, 263; U.S.D., 1947, 1500; Wehmer, II, 1032).

The root contains stachyose and an unidentified glycoside hydrolysed by emulsin. It is considered astringent and used as resolvent and vulnerary in Spain. The flowers are sweetish in taste and are used as mild astringent, haemostatic, hypnotic and depurative in bleeding piles; they are useful against fluor albus, chlorosis and debilities. The flowers contain choline, mucilage, quercetin, isoquercitrin, kaempferol and kaempferol 3-glucoside, a catechol tannin (5.2%) and volatile oil (0.05%). The leaves are edible; they are a good source of carotene and also contain ascorbic acid (Wehmer, II, 1032; Caius, *J. Bombay nat. Hist. Soc.*, 1940-41, **42,** 393; Steinmetz, II, 263; Hocking, 122; *Chem. Abstr.*, 1959, **53,** 13282; 1954, **48,** 10138).

L. amplexicaule Linn. (Henbit) is a decumbent, much-branched annual herb, 10–30 cm. high, with orbicular leaves and purple red flowers, found in temperate Himalayas from Kashmir to Kumaon up to 3,000 m., Sikkim and Aka hills in Assam. The plant is considered stimulant, laxative, diaphoretic, antirheumatic and cephalic. It contains carotene and ascorbic acid. In Queensland and New South Wales, the plant is reported to cause poisoning of cattle

(Hocking, 122 ; Jacobs & Burlage, 113 ; *Chem. Abstr.*, 1949, **43,** 3536 ; Forsyth, *Bull. Minist. Agric., Lond.*, No. 161, 1954, 102 ; Connor, *Bull. Dep. sci. industr. Res. N.Z.*, No. 99, 1951, 106).

LAMPRACHAENIUM Benth. (*Compositae*)

D.E.P., IV, 586 ; Fl. Br. Ind., III, 228.

A monotypic genus, represented by *L. microcephalum*, distributed in the Indo-Malayan region.

L. microcephalum Benth. (Bombay—*Brahmadandi*) is a herbaceous, erect, much-branched annual with elliptic leaves, small purple flowers in numerous small heads and minute, obovoid achenes, found in Deccan, Konkan and Mysore at altitudes of 1,200–1,500 m. The plant, which has the odour of chamomille (*Matricaria chamomilla* Linn.), is used as an aromatic bitter. It is said to possess antiseptic properties (Kirt. & Basu, II, 1321 ; Chopra, 1958, 597).

Langsat — *see* **Lansium**

Langurs — *see* **Monkeys and Apes**

LANNEA A. Rich (*Anacardiaceae*)

A genus of trees distributed in Africa and South-East Asia. One species is found in India.

L. coromandelica (Houtt.) Merrill syn. *L. grandis* Engl. ; *Odina wodier* Roxb.

D.E.P., V, 445 ; Fl. Br. Ind., II, 29 ; Troup, I, 245, Fig. 98.

Hindi—*Jhingan, kaimil, mohin* ; Beng.—*Jiyal, jeol, bhadi* ; Mar.—*Moi, shimti* ; Guj.—*Mavedi* ; Tel.—*Appriyada* ; Tam.—*Wodier, kalasan* ; Kan.—*Ajasringi, kuratige, gojal* ; Mal.—*Odiya maram* ; Oriya—*Indramai, moi.*

Nepal—*Halonre, thulo dabdabe* ; Lepcha—*Dang-paguel-kung* ; Assam—*Jia* ; Rajasthan—*Gobi* ; Andamans—*Nanum, nabe.*

Trade—*Jhingan, wodier.*

A moderate-sized to large deciduous tree with spreading crown and stout branches, attaining a height up to 24 m., found throughout the greater part of India and the Andaman Islands, ascending to an altitude of 1,500 m. in the Himalayas. Bark grey or whitish, smooth, exfoliating in irregular rounded plates ; leaves imparipinnate, 25–45 cm. long, crowded at the ends of branches : leaflets 7–9, oblong-ovate, 7.5–15 cm. × 2.5–5 cm. ; flowers small, yellowish or purplish, unisexual : male fascicled, in slender compound racemes, female in simple pubescent racemes ; fruit red, compressed, reniform, 1-seeded. The tree occurs in sub-Himalayan sal (*Shorea robusta* Gaertn. f.) forests and is common in the mixed deciduous forests of outer hills and plains, especially in dry places. It is often planted in avenues and used for hedges and boundaries, but has the disadvantage of being leafless during the hot season.

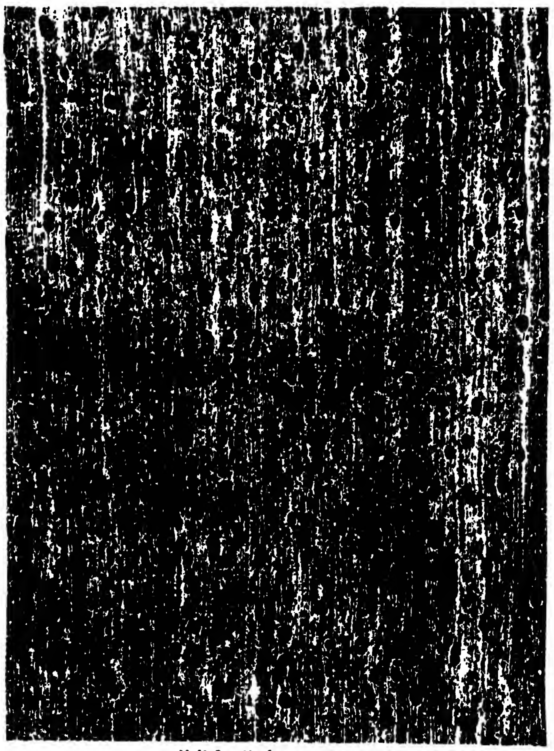
Jhingan grows on various geological formations, including sandstone, limestone, metamorphic rocks, traps and sometimes laterite. It attains its maximum development on well-drained deep alluvial or diluvial soil, but avoids swampy and badly drained situations. It is a light-demander and drought- and fire-resistant, but is susceptible to frost. It coppices and pollards well and produces root suckers (Kadambi, *Indian For.*, 1950, **76,** 529 ; Khan, ibid., 1952, **78,** 311 ; Troup, I, 245).

Natural reproduction by seed is generally adequate and occurs only on deep soil. Seeds are dispersed by birds, which eat the fruits. Artificial reproduction may be done by direct sowing or by transplanting nursery-raised seedlings or stumps, preferably a year old. The seeds, however, do not retain their viability for long and the germinating capacity is only c. 43%. The tree may also be propagated by branch cuttings ; 2–3 year old branches succeed better than older ones. Tree stumping in Mysore has proved successful. Data relating to rate of growth are scanty : the reported average diameters of 10 year old and 15 year old trees in Madhya Pradesh are respectively 25.5 cm. and 46.25 cm. The rate of growth of coppice shoots is reported to be fast. Jhingan is usually treated as an accessary species and no specific silvicultural treatment has been prescribed for it (Kadambi, loc. cit. ; Khan, loc. cit. ; Benthall, 130 ; Troup, I, 246 ; Mathauda, *Indian For.*, 1955, **81,** 617).

Jhingan is subject to the attack of rust (*Phacospora odinae* Mundkur), brown leaf rust [*Cerotelium lanneae* (V. Hoehn.) Arth.] and leaf spot (*Meliola geniculata* Syd. & Butler). Among insect pests, botrychid beetle (*Heterobostrychis aequalis* Waterh.) and a few other borers of felled timbers, are known to attack green logs and converted timber. *Plocaederus obesus* Gahan., a cerambycid beetle, also attacks felled timber, but not the living tree ; the larva of this insect pupates inside the wood in wide galleries, sometimes 15 cm. deep from the surface. *Pachydissus* sp., *Xyleborus parvulus* Eichhoff. and *Glenea multiguttata* Guer. also attack the tree. The grubs of the last species feed on the bast (Kadambi, loc. cit. ; *Indian J. agric. Sci.*, 1950, **20,** 107 ; Gamble, 219 ; Stebbing, 295, 336, 378, 594).

The sapwood of jhingan is white to yellowish white when first exposed, turning brownish grey, sometimes with a purplish cast, with age. The heartwood is light pinkish red to light red, turning red or brownish red with age, rather lustrous, straight or narrowly interlocked- and close-grained, medium- and even-textured, fairly strong, moderately hard and light (sp. gr., *c.* 0.55 ; wt., *c.* 36 lb./cu. ft.). Considerable variations in the weight of wood have been recorded, probably due to the variations in sapwood and heartwood (Pearson & Brown, I, 337–38 ; Trotter, 1944, 131).

The wood is difficult and slow to season. It should be converted soon after felling and sapwood and heartwood should be treated separately. The sapwood forms the bulk of the log and it is liable to split and discolour : it dries more quickly than the heartwood. Sawn stock should be open-stacked under cover and ends of boards and scantlings treated with paraffin wax, resin or tar and pitch to prevent end-splitting. The wood can be kiln-dried in 8–10 days ; in addition to initial steaming, one intermediate steaming and one steaming towards the end for 2–3 hours at 55° & 100% R.H. are necessary. The presence of gum makes kiln-drying difficult (Pearson & Brown, I, 338 ; Trotter, 1944, 131 ; Rehman, *Indian For. Bull., N.S.*, No. 198, 1956, 2).



F.R.I., Dehra Dun. Photo : S. S. Ghosh

FIG. 16. LANNEA COROMANDELICA—TRANSVERSE SECTION OF WOOD (×10)

The sapwood perishes rapidly in exposed positions and is liable to insect attack, particularly if it is not well seasoned. It is moderately durable under cover and in contact with water. The heartwood is fairly durable ; it is very refractory to treatment with preservatives, the end and side penetrations being practically nil. The timber saws, works and turns easily. The grain is often interlocked in broad bands and if cut on a tangent, the wood has to be carefully planed to prevent fibres from picking up. With proper care it finishes well and takes a fine polish (Pearson & Brown, I, 339 ; Trotter, 1944, 131–32 ; Purushotham *et al., Indian For.*, 1953, **79,** 49).

The data for the comparative suitability of jhingan timber, expressed as percentages of the same properties of teak, are: wt., 80 ; strength as a beam, 55 stiffness as a beam, 50 ; suitability as a post, 50 shock-resisting ability, 75 ; retention of shape, 85 shear, 80 ; and hardness, 70 (Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** Sheet No. 12).

Jhingan is used locally, over a large part of India, for house building, packing cases, furniture, wheel spokes, cattle yokes, oil presses, rice pounders, plough shafts, spear shafts, combs, brush backs, wooden jars, mine props, cutting blocks, boot lasts, troughs, well construction, dug-outs and boats. It is used also for carving and turnery. It is suitable for commercial plywood and tea chests, slack cooperage, bobbins, rollers in jute mills, inferior pencils, second quality slate frames, and railway sleepers after treatment. It may be used for match sticks, but is rather hard for the purpose (Pearson & Brown, I, 339–40 ; Gamble, 219 ; Trotter, 1944, 198, 207 ; *Indian For.*, 1952, **78,** 276–78 ; Rehman & Ishaq, *Indian For. Leafl.*, No. 66, 1945, 7 ; Rehman *et al., Indian For.*, 1954, **80,** 626).

The wood is used, in admixture with other woods, as fuel (calorific value, 4,933 cal., 8,880 B.t.u.). Destructive distillation gave the following products (dry basis): charcoal, 35.4 ; pyroligneous acid (including acid, 5.72 ; esters, 3.93 ; acetone, 2.42 ; methanol, 1.26%), 35.9 ; tar, 7.8 ; pitch & losses, 2.2% ; and gas (at N.T.P.), 1.89 cu. ft./lb. (Cox, *Indian For. Bull.*, No. 43, 1921 ; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 19 ; Kedare & Tendolkar, *J. sci. industr. Res.*, 1953, **12B,** 217).

The wood has been tried for the production of chemical and semi-chemical pulps. Analysis of wood gave the following values (dry basis): cellulose,

53.37; lignin, 24.11; pentosans, 15.40; and ash, 1.6%. Chemical pulp obtained by the sulphate process (22% total alkali in 5% conc.; cooking temp., 153°; cooking time, 6 hr.; yield of bleached pulp, 46.2%) is suitable for the manufacture of writing and printing papers. As the fibres are of short length (av. 1.01 mm.; ratio of length to diam., 41.1), the pulp should be used in admixture with long fibred pulps from bamboo or sabai (*Eulaliopsis binata*). Semi-chemical pulp suitable for brown wrapping paper has been produced by the neutral sulphite process (sodium sulphite, 15–18%; digestion temp., 170°; digestion period, 3 hr.; yield of pulp, 65 67%). Both chemical and semi-chemical pulps are easy to bleach and possess satisfactory strength properties (Bhat & Guha, *Indian For.*, 1951, **77,** 568).

A mucilaginous gum, known as Jhingan gum, exudes from wounds and cracks in the bark. It is often fouled by the excreta of a boring insect and is also mixed with tannin which filters from the bark. In North India, the gum is tapped from March till the beginning of rains by making shallow cuts in the bark. The yield of gum is *c.* 10 lb. per tree during the first year of tapping but decreases to *c.* 2 lb. after 5 years, when trees are given rest. The gum occurs in round tears or colourless fissured angular fragments like gum arabic. It is yellowish white when fresh, turning brown and ultimately black on drying. Fresh gum is soluble in water, forming a rather thin mucilage with good adhesive properties: it possesses about three-fourths of the viscosity of gum arabic. It is used in calico-printing, paper and cloth sizing, inferior varnishes and inks, in plastering and white washing and for preserving fishing nets. It is also used in confectionery: small quantities of the gum are reported to be exported from India for this purpose (Yates, *Agric. Ledger*, 1900, 169; Burkill, II, 1313; Kadambi, loc. cit.; Trotter, 1940, 283; Gamble, 219; Howes, 1949, 58).

The gum can be purified by precipitation with alcohol. A fairly white product (ash content, 2.7%) which does not darken on keeping is obtained. On mild hydrolysis, *l*-arabinose, *d*-galactose and a complex monobasic acid, named jeolic acid, which forms a colloidal solution in water, are obtained. Jeolic acid has properties similar to those of arabic acid (from gum arabic) and appears to exist in the gum as calcium, magnesium and potassium salts; on further hydrolysis it yields an aldobionic acid ($C_{12}H_{20}O_{12}$), identified as galactose-galacturonic acid (Mukherjee & Banerjee, *J. Indian chem. Soc.*, 1948, **25,** 59, 63; Mukherjee & Chakravarti, ibid., 1948, **25,** 113; Mukherjee, ibid., 1948, **25,** 333; 1953, **30,** 201).

The gum may be used as a flocculating agent for the clarification of sugar cane juice: it is comparable to the imported synthetic product, Lytron-X 886 in clarification efficiency. It aids fast settling of impurities and yields a bright and clear juice (Chatterjee & Mukherjee, *Proc. Indian Sci. Congr.*, 1957, pt III, 155).

The bark contains *c.* 8% phlobatannin ($C_{15}H_{14}O_7$) and may be used for tanning and dyeing purposes and as a preservative for fishing nets. The bark extract dyes cotton, with or without mordant, and imparts shades ranging from light brown to black which are moderately fast; dyed samples may be topped with basic dyestuffs to give brilliant shades: the shades may be modified also by coupling with diazotized and stabilized salts of the Fast Salt series. The bark extract can also be used for textile printing and for dyeing silk and wool [Nair & Punnose, *Bull. Res. Inst., Univ. Travancore*, 1950, **1A** (1), 87; Punnose, *Rep. Dep. Res., Univ. Travancore*, 1939–46, 183].

The bark is acrid and astringent: it is used as a lotion for bruises, wounds, sores, ulcers and sore eyes. The gum is given in asthma and as a cordial to women during lactation. The bark has stimulant properties and is reported to be used in gout: it is used in decoction for aphthae of the mouth and toothache. Boiled leaves are applied in sprains and bruises, local swellings, pains of body and in elephantiasis. In Bengal, the juice of the green branches mixed with tamarind is given as an emetic in cases of coma or insensibility produced by opium or other narcotics (Kirt. & Basu, I, 665–66; Chopra, 511; Nadkarni, I, 868).

Jhingan is a good fodder tree for cattle, sheep, goats and especially elephants. The bark yields a strong fibre (Laurie, *Indian For. Leafl.*, No. 82, 1945, 3; Kadambi, loc. cit.; Rodger, 94).

Lanolin — *see* **Fats and Oils**

LANSIUM Correa (*Meliaceae*)

A small genus of trees distributed in India and Malaysia. Three species have been recorded in India, of which two are wild; the third is a Malayan species cultivated for its edible fruit.

L. anamallayanum Bedd.

Fl. Br. Ind., I, 558; Talbot, I, 237, Fig. 140.

TAM.—*Sandana virai*; KAN.—*Chigadmari*; MAL.—*Vandakamin.*

KERALA—*Thevathali.*

A handsome, dark leaved, medium-sized tree, c. 15 m. high, found in the forests of western ghats in Kanara, Wynaad, Anaimalai hills, Travancore and Tinnevelly at elevations of 450-900 m. Leaves 15 23 cm. long, pinnately compound with 3–5 alternate leaflets; flowers yellowish white, polygamo-dioecious, in spikes or panicles; fruits 1–5 celled, oblong, as big as large grapes; seeds one or two enclosed in a juicy pulp.

The tree is found growing gregariously in isolated patches in evergreen forests, particularly at altitudes of c. 600 m. It flowers during March–May and fruits, which are said to be edible, ripen during the rainy season. The wood (wt., 62 lb./cu. ft.) is hard, sweet scented, insect resistant, pale yellowish white or pink and close-grained; medullary rays very fine and numerous giving a satiny silver grain on a radial section. It is not much used because it is available only in small sizes (Bourdillon, 76 77; Talbot, I, 237; Gamble, 150)45,307

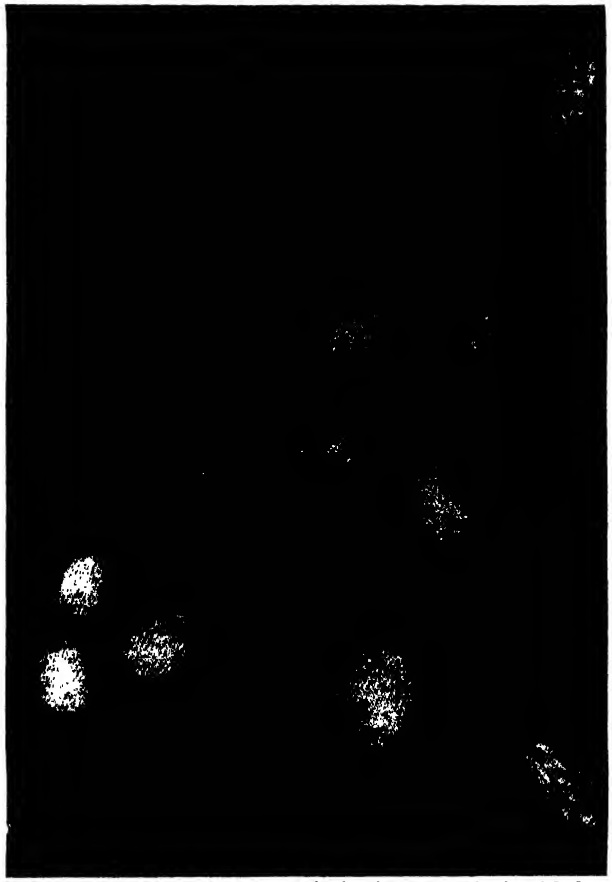
The wood on steam-distillation yields 2.1–2.2% of a colourless or pale yellow essential oil which, on standing and exposure to light, turns deep yellow and viscous. The oil has a pungent bitter taste and a characteristic woody odour, suggestive of sandal wood oil, but more resinous and harsh. It has the following constants: sp. gr.$^{25°}$, 0.8978; $n_D^{24°}$, 1.4950; $[\alpha]_D$, −128°; acid val., nil; ester val., nil; acet. val., 8; solubility in 95% alcohol, 1 in 4 vol. The oil contains bisabolene and α-chigadmarene ($C_{15}H_{24}$, b.p. 117–18°/9 mm.) as the chief constituents (Jois *et al.*, *J. Mysore Univ.*, 1941, **1B,** 171; Rao *et al.*, *J. Indian chem. Soc.*, 1952, **29,** 604, 620).

L. domesticum Correa LANGSAT, DUKU

Fl. Br. Ind., I, 558; Brown, 1941, II, Fig. 135.

A rather slender, but fairly tall, tree with fluted trunk, cultivated in Kallar and Burliar Fruit Stations in Nilgiris and in a few other places in South India. Leaves pinnately compound, 23–45 cm. long, with alternate leaflets; flowers yellow, solitary and in clusters borne on hairy spikes springing from trunk or old branches; fruits 2.5–5 cm. in diam., round or oblong, densely pubescent; seeds 1–5, often only one, surrounded by a sweet, white, translucent and juicy pulp.

The plant is a native of Malaysia where its fruits are esteemed as dessert. They resemble loquat to some extent and occur in bunches like grapes. They have a pubescent and aromatic skin, which does not adhere to the inner pulp, the latter separating into five or less distinct segments, as in an orange. Two varieties are under cultivation: var. *domesticum* (Duku) bearing oblong ovoid or ellipsoid fruits with thin pericarp and little milky juice, and var. *pubescens* (Langsat) yielding sub-globose fruits with thick pericarp and much milky juice. Good types among both, particularly the smaller seedless types which are sweetish, are valued for edible purposes (Burkill, II, 1314; Bailey, 1947, II, 1818; Ochse, 62; Corner, I, 463; Popenoe, 428).



Horticulturist, Dep. Agric., Madras

FIG. 17. LANSIUM DOMESTICUM—FRUITING BRANCH

The plant can be grown in any soil but it is not economical to grow them in areas with a prolonged dry season. It is commonly propagated by seeds which are sown soon after they are removed from the fruit. Trees grown from seeds come to bearing in *c.* 15 years. Propagation by cleft and side grafting is recommended for choice forms; marcottage is said to be difficult. Budding on stocks of Duku itself has given satisfactory results. A spacing of

8–10 m. between plants is allowed while planting in the field. The fruits are harvested from April to September and an average annual yield of 30 lb. of fruits per tree has been reported from Nilgiris (Popenoe, 428; Ochse, 62; Corner, I, 463; Naik, 407).

The edible pulp constitutes *c.* 60% of the fruit (wt., 15–25 g.). It has a delicious, sub-acid taste and may be preserved in syrup or candied. Analysis of edible portion gave the following values: moisture, 86.5; protein, 0.8; ether extr., 0.3; carbohydrates, 9.5; fibre, 2.3; and mineral matter, 0.6%: calcium, 20.0 mg.; phosphorus, 30.0 mg.; iron, 0.5 mg.; carotene (as vitamin A), 13.0 i.u.; thiamine, 89 μg.; riboflavin, 124 μg.; and ascorbic acid, 1.0 mg./100 g.; niacin was absent. The presence of phytin (1.1%, dry basis) has been reported (Thorpe, VII, 177; Quisumbing, 480; Belavady & Balasubramanian, *Indian J. agric. Sci.*, 1959, **29**, 151).

Langsat fruits do not keep well. Cold storage studies have shown that they can be preserved in good condition for about two weeks at 52–55°F., relative humidity, 85–90%. Total soluble solids and reducing sugars increase during storage, while acidity increases up to seven days and thereafter decreases (Srivastava & Mathur, *J. Sci. Fd Agric.*, 1955, **6**, 511).

The peel of the fruit is thin but tough, and it exudes a large amount of sticky latex. The stickiness can be avoided by dipping the fruit in boiling water before eating. The peel emits an aromatic odour, like incense when burnt and it is used in Java as a mosquito repellent. Fresh peel yields 0.2% of a pale yellow volatile oil (sp. gr.$^{25°}$, 0.8819; $n_D^{25°}$, 1.5155), a brown resin (3.5%) and some reducing acids. Dried peel yields a dark coloured, semi-liquid oleoresin containing 0.17% volatile oil and 22% resin. The resin is non-toxic and useful in diarrhoea and intestinal spasms (Brown, 1941, II, 268; Quisumbing, 480–82; *Chem. Abstr.*, 1932, **26**, 806; 1940, **34**, 7007).

The seeds are bitter. They contain traces of an alkaloid, an alcohol-soluble resin (yield, 1%; acid val., 64.2; sap. val., 267), and two slightly toxic, bitter, substances. They are used as vermifuge and febrifuge (Burkill, II, 1315; Wehmer, II, 662; Thorpe, VII, 177).

The wood (wt., 52.3 lb./cu. ft.) is light coloured, not very hard but durable, tough and elastic. It is used in Java for tool handles and house posts. It is also used for rafters. The bark is astringent and used in decoction for dysentery (Desch, 1954, II, 354; Burkill, II, 1315).

LANTANA Linn. (*Verbenaceae*)

A genus of herbs, undershrubs or shrubs, distributed mostly in tropical and sub-tropical America; a few species have been recorded in the tropics of the Old World. Seven or eight species occur in India.

L. camara Linn.

Bailey, 1949, 842.

A hairy, unarmed or slightly prickly shrub, 0.3–1.8 m. or more in height, native of tropical America and cultivated as an ornamental or hedge plant. Leaves opposite, ovate or oblong-ovate, crenate-dentate, rather thick, rugose, scabrous above, pubescent beneath; flowers small, usually yellow or orange changing to red or scarlet, in dense axillary heads; fruit drupaceous, 5 mm. diam., greenish black.

Numerous varieties and types of *L. camara* are met with; some of them are polyploids. The varieties and types are so intermixed that it is difficult to differentiate between them morphologically. Most of them have recurved prickles on the stem, but under cultivation they become less prickly or even unarmed, less vigorous in growth, and they set seed less freely. Dwarf types have been developed for growing in borders and hanging baskets.

Of the many known varieties of *L. camara*, three have been reported from India, viz. var. *aculeata* Moldenke, var. *mista* Bailey and var. *nivea* Bailey. Among them *L. camara* var. *aculeata* is the most common. The occurrence of *L. camara* proper in India is doubtful (Bailey, 1947, II, 1819; Sen & Sahni, *Sci. & Cult.*, 1954–55, **20**, 558; Natarajan & Ahuja, *J. Indian bot. Soc.*, 1957, **36**, 35; Moldenke, 163).

——— var. **aculeata** Moldenke syn. *L. aculeata* Linn.; *L. camara* auct., non Linn. LANTANA, WILD SAGE

D.E.P., IV, 586; Fl. Br. Ind., IV, 562.

MAR.—*Chadurang, ghaneri*; TEL. *Pulikampa*; TAM.—*Unnichedi*; KAN.—*Nata hu gida, hesike, kakke*; MAL.—*Arippu*.

MADHYA PRADESH—*Raimuniya*.

A low, erect or sub-scandent shrub, 1.2–2.4 m. high, with stout recurved prickles and a strong odour of black currants, introduced into India as an ornamental and hedge plant, now completely naturalized and found throughout India. Leaves opposite, ovate or ovate-oblong, acute or subacute, crenate-serrate,

FIG. 18. LANTANA CAMARA VAR. ACULEATA—FLOWERING AND FRUITING BRANCHES

rugose above, scabrid on both sides ; flowers small, in axillary heads, usually orange, sometimes varying from white to red ; fruit drupaceous, small, greenish blue black or blackish, shining, with two nutlets.

Lantana grows under varying conditions of climate and soil ; it thrives in moist areas of high rainfall exceeding 200 in. and also in comparatively dry localities with 30 in. rainfall per annum. It grows in rich as well as poor soils, including gravel and laterite, and in low lying areas and on hills up to 1,800 m. It is drought-resistant, light-loving and tolerates moderate shade. It propagates readily from stumps or cuttings and from seeds which are disseminated by birds through droppings. It is of vigorous growth and requires to be cut down or trimmed to keep it within limits. It regenerates quickly after cutting, trampling or burning and forms a dense impenetrable thicket. It blossoms and bears fruits almost throughout the year (Troup, II, 781-82 ; Iyengar, *Curr. Sci.*, 1932-33, **1**, 266).

Due to its prolific growth and wide adaptability, lantana has overrun large areas in India and has developed into a serious pest. Infested areas include cultivable and waste lands, forest areas, grazing and pasture lands and some plantations. The areas worst affected are parts of Deccan and portions of Coorg, Wynaad, Nilgiris and lower hills of western ghats ; it has also invaded parts of Uttar Pradesh (*bhabar* tract around Haldwani and outskirts of Dehra Dun), Chota Nagpur (Bihar) and the neighbourhood of Shillong (Assam) (Troup, II, 780, 782 ; Iyengar, loc. cit. ; Mudaliar & Rao, 327).

Lantana is a source of fire hazard in deciduous forests. Because of its ability to burn even when green, it causes serious destruction of forest crops. In Java, lantana undergrowth in teak plantations has affected the growth of teak plants, reducing the basal area increment by 33%. In some areas, lantana harbours injurious insect pests, including malarial mosquitoes (Troup, II, 781-82 ; Trevor & Champion, 217 ; Venkataramany, *Indian For.*, 1956, **82**, 225 ; Iyengar, loc. cit.).

Complete eradication of lantana over large areas is difficult and costly. Various methods, mechanical, cultural, chemical and biological, have been tried to check the spread of lantana.

Control measures by mechanical means include stumping of plants in February or March up to a height of 1 ft. above the ground and burning the cuttings ; the stumps left behind are pulled out in the rainy season when the ground is soft. Frequent uprooting of regrowth, which appear after the first cutting, for 2-4 years is essential to keep the pest under control. Another method suggested is to cut the branches and heap the debris around the roots to prevent regeneration of new shoots ; the debris is then burnt followed by digging up of the root system and burning.

Cultural control has been attempted by planting *Ricinus communis* Linn. or *Ficus elastica.* In Indonesia, planting of *Leucaena glauca* Benth. has been tried, while in Ceylon, *Tithonia diversifolia* A. Gray is reported to have given good results (Troup, II, 781, 783 ; Iyengar, loc. cit. ; Prasad, *Indian For.*, 1949, **75**, 94 ; Walandouw, *J. sci. Res. Indonesia*, 1952, **1**, 205 ; Petch, *J. Indian bot. Soc.*, 1921, **2**, 302).

Control of lantana by the use of chemicals has given useful results. One of the methods tried consists in cutting the plants close to the ground and

painting cut ends with sodium arsenate; the treatment is effective but is not recommended as it involves the hazard of poisoning livestock which may stray into the treated area. In recent years various herbicides have been applied and successful control has been achieved. Painting of cut ends with 2,4-D solution (10%) gives effective control. Trials carried out at the Agricultural Research Station, Ambalavayal and the Fruit Research Station, Kallar (Madras State) have shown that shrubs cut to a height of 2 ft. from the ground and sprayed with 2,4,5-T (20 lb. in a spray volume of 150 gal./acre), using Teepol as wetting agent, withered in 15 days. Spraying trials at the Forest Research Institute, Dehra Dun, show that Y.F. 2717–2,4,5-T, *n*-butyl ester is effective even when the plants are not cut back. Formulations containing 2,4,5-T alone or in combination with 2,4-D are more effective than 2,4-D alone, especially in large bushes. Regrowth, after cutting back, can be completely controlled by spraying with Dicotox, Esteron 44 (active principle, 2,4-D ester), MCPA and Fernoxone [Kumar & Solomon, *Poona agric. Coll. Mag.*, 1952–53, **43,** 61; Narayanan & Thyagarajan, *Indian Fmg, N.S.*, 1958–59, **8**(1), 14; Kadambi & Dabral, *Indian For.*, 1954, **80,** 574; *Hort. Abstr.*, 1951, **21,** 62; *For. Res. India*, 1950–51, pt II, 74; *Field Crop Abstr.*, 1952, **5,** 233; *Indian hort. Abstr.*, 1957, **7**(1), 23].

Biological control of lantana by insects is reported to have met with some success in Hawaii and Fiji islands: lantana bug (*Orthezia insignis* Dougl.), lantana seed fly [*Ophiomyia* (*Agromyza*) *lantanae* Frog.] and lantana lace bug (*Teleonemia scrupulosa* Stal) feed on stems, leaves, flowers and seeds and prevent the spread of the plant. The introduction of foreign insects into India for lantana control has been attempted, but it has not been pursued pending further knowledge on the effect of the introduction on other plants (Thistle, *World Crops*, 1957, **9,** 447; Wlth India—Raw Materials, V, 224; Troup, II, 781; Puttarudriah, *Mysore agric. J.*, 1954, **30,** 70).

Although lantana is a serious pest, it may prove beneficial under certain conditions in forests. It improves the fertility of exhausted areas, and rocky, gravel or hard laterite soils. It enriches the soil and serves to retain humus in deforested areas and checks soil erosion. It is a nurse plant for sandalwood seedlings, though the latter do not survive under a dense growth of lantana; its use as nurse plant is not recommended as it is believed to have connection with the spike disease of sandal, though no definite evidence has been produced to incriminate lantana with the incidence or spread of the disease (Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 102; Troup, II, 782; III, 809, 812; Cameron, 214; Walandouw, loc. cit.; Talbot, II, 345).

The leaves and twigs of lantana are occasionally used as green manure in forest areas and for paddy crops in Mysore: they can also be composted along with other materials. Analysis of green material gave the following values: nitrogen, 0.88; phosphorus (P_2O_5), 0.15; potassium (K_2O), 0.90; and calcium (CaO), 0.61%. Lantana ash (ash content, 10.29%) is rich in soluble potassium salts and useful for manuring coconut trees: it is also rich in manganese (0.3–0.4%) (Yegna Narayan Aiyer, 21; Iyengar, *Mysore agric. J.*, 1956, **31,** 5; Pillai *et al.*, *Agric. J. India*, 1930, **25,** 143; *For. Res. India*, 1949 50, pt II, 53; Mata Prasad & Dange, *Indian For. Leafl.*, No. 95, 1947, 4, 18; Nigam *et al.*, *Res. & Ind.*, 1957, **2,** 194).

Lantana leaves have been tried as a substitute for tea; fermented leaves possess a mild odour, which is not unpleasant, and yield an inferior beverage. The leaves contain a powerful oxidase: they also contain catalase, amylase, invertase, lipase, tannase(?) and glucosidase. Appreciable amounts of tannins and sugar, and a resin occur in leaves; a crystalline glucoside (probably $C_{27}H_{42}O_4$) has been separated from the resin by ether extraction (Behram, *J. Indian Inst. Sci.*, 1918–20, **2,** 195).

The leaves yield (0.2%), on steam-distillation, a yellow or greenish yellow oil with a pleasant and lasting odour reminiscent of sage (*Salvia officinalis* Linn.). The constants of the oil are as follows: sp. gr.$_{4°}^{30°}$, 0.8842; n, 1.4899; $[\alpha]_D^{30°}$, +14.7°; acid val., 1.6; sap. val., 4.6 (after acetylation, 23.4); sol. in 5 vol. or more of 97% alcohol. On standing, the oil becomes viscid and insoluble in alcohol. The principal constituents of the oil are a sesquiterpene (80%), probably caryophyllene, and *l*-α-phellandrene (10–12%); small amounts of aldehydes (2.4%) and alcohols are present. The leaf oil is not of any direct value in perfumery. It is used in the treatment of itches of skin and may also be useful as an antiseptic for wounds (Iyengar, *Curr. Sci.*, 1932–33, **1,** 266; Sayeeduddin & Salam, ibid., 1932–33, **1,** 330; Kanga, *J. Indian Inst. Sci.*, 1914–18, **1,** 93; Moudgill & Vridhachalam, *Perfum. essent. Oil Rec.*, 1922, **13,** 173).

The leaves contain a toxic principle lantadene A (angeloyloxy-oleanonic acid, $C_{35}H_{52}O_5$, m.p. 282–86°) which causes acute photosensitization and severe icterus in sheep. It also contains a triterpenoid,

lantadene B (dimethylacryloyloxy-oleanonic acid, $C_{35}H_{52}O_{5}$, m.p. 293-94° decomp.) which is inactive, and a steroid, lancamarone ($C_{28}H_{40}O_{4}$, m.p. 280° decomp.) which is a fish poison (up to 1 : 1,000,000 dilution) and is cardioactive. The bark of stems and roots contain a quinine-like alkaloid, lantanine, with strong antipyretic and antispasmodic properties. Acid extracts of the shoot show antibacterial activity against *Escherichia coli ;* acetated buffer extracts are active against *Micrococcus pyogenes* var. *aureus* (*Chem. Abstr.*, 1944, **38,** 6297 ; 1948, **42,** 9086 ; Barton *et al.*, *J. chem. Soc.*, 1954, 3989 ; 1956, 4160 ; Nigam *et al.*, *J. sci. industr. Res.*, 1957, **16B,** 514 ; van Steenis-Kruseman, *Bull. Org. sci. Res. Indonesia*, No. 18, 1953, 49 ; Dalziel, 455 ; Joshi & Magar, *J. sci. industr. Res.*, 1952, **11B,** 261).

The flowers yield 0.07% of a volatile oil similar to that of leaf oil ; the characteristics of the oil are: sp. gr.$^{26}_{15°}$, 0.915 ; $n_D^{26.5°}$, 1.4987 ; $[\alpha]_{Hg}$, +23.9° ; sap. val., 10 ; and acet. val., 43.6. The flowers contain anthocyanins, a yellow flavone, a pink pigment and carotene (Kanga, loc. cit. ; Sathe & Subrahmanyan, *Proc. Indian Sci. Congr.*, 1929, 241 ; Pillai *et al.*, loc. cit. ; Lal, *Proc. nat. Acad. Sci. India*, 1936, **6,** 128).

The seeds contain a fixed oil (9%) with the following characteristics: sp. gr.$^{23.5°}$, 0.9788 ; $n^{40°}$, 1.3508 ; acid val., 22.16 ; sap. val., 192.6 ; iod. val., 108.5 ; and unsapon. matter, 3.5%. The component fatty acids are linolenic, linoleic, oleic, stearic and palmitic (Nigam & Kaul, *J. sci. industr. Res.*, 1958, **17B,** 472).

The plant is not relished by cattle but is reported to be browsed when pasturage is scarce. It is, however, considered poisonous ; cattle fed on leaves (12–16 oz.) developed symptoms of severe jaundice, exfoliation of skin near muzzle, profuse salivation, severe dermatitis and copious lachrymation ; the animals lost appetite and appeared dull. Post-mortem disclosed profuse colouration of abdominal organs with bile pigments ; the liver was congested and considerably enlarged (Chopra *et al.*, 47 ; *Annu. Rep. Indian vet. Res. Inst.*, 1950-51, 46).

The fruits of the plant are edible. Stems are used as tooth brush and leaves for polishing wood. In Guiana and Reunion, the plant is considered vulnerary, diaphoretic, carminative and antispasmodic. It is useful for fistulæ, pustules and tumours. A decoction of the plant is given in tetanus, rheumatism, malaria and atoxy of abdominal viscera. In Philippines, a decoction of fresh roots is used as gargle for toothache. Pounded leaves are applied to cuts, ulcers and swellings ; a decoction of leaves and fruits is used as a lotion for wounds. An infusion of leaves is taken internally for bilious fevers and catarrhal affections ; externally it is used in the form of lotion or fomentation against eczema eruptions and rheumatism. An infusion of flowers is given as pectoral for children [Burkill, II, 1317 ; Dalziel, 455 ; Kirt. & Basu, III, 1914–15 ; *J. sci. Res. Indonesia*, 1952, **1** (suppl.), 29 ; Quisumbing, 796–97].

The stalks have been tried as a raw material for paper pulp. Analysis of stalks gave the following values (dry basis): furfuroids, 21.6 ; lignin, 14.0 ; α-cellulose, 30.6 ; and ash, 3.50%. Digestion with lime and kollerganging yielded 63.7% of pulp suitable for wrapping paper and straw board. Pulp suitable for writing and printing paper is obtained by sulphate process (yield: unbleached pulp, 38.0% ; bleached pulp, 34.4%) (*For. Res. India*, 1954-55, pt I, 104, 106, 108 ; Pillai *et al.*, loc. cit.).

L. indica Roxb. is often grown in gardens. The ash of the plant is a fair source of potassium (1.1–1.8%) and phosphorus (1.6–2.2%). The plant is also reported to contain a hydrocarbon (m.p. 78°). The leaves of *L. rugosa* Thunb. syn. *L. salvifolia* Jacq. are said to be used in parts of Africa for flavouring food and milk. They are also considered medicinal (*For. Res. India*, 1951-52, pt II, 159 ; Nigam *et al.*, *J. sci. industr. Res.*, 1957, **16B,** 514 ; Dalziel, 455 ; Watt & Breyer-Brandwijk, 154).

LAPORTEA Gaudich. (*Urticaceae*)

A genus of perennial herbs, shrubs or small trees, often with stinging hairs, found mostly in the tropics ; a few extra-tropical species are met with in North America. Five species occur in India.

L. crenulata Gaudich. syn. *L. stimulus* Miq. DEVIL NETTLE, FEVER NETTLE

D.E.P., IV, 587 ; II, 567 ; C.P., 162, 924 ; Fl. Br. Ind., V, 550 ; Kirt. & Basu, Pl. 908.

HINDI—*Utigun ;* BENG.—*Chorpata ;* TAM.—*Ottapilavu ;* MAL.—*Anachoriyan.*

ASSAM—*Torash, sorot-gach ;* LUSHAI—*Thlak-pui ;* GARO—*Gilmat-jakma ;* LEPCHA—*Ongyalop ;* NEPAL—*Moringe.*

A large stout shrub or small tree, 3–4 m. high, found growing gregariously in evergreen forests in tropical Himalayas from Nepal eastwards, Bihar, Chota Nagpur, N. Bengal, plains and hills of Assam, Rampa hills in N. Circars, Anaimalai hills and western ghats in Kerala at altitudes of 300–1,500 m.

Bark white, smooth, thin; leaves oval to oblong or oblong-lanceolate; flowers minute, greenish, dioecious, in axillary cymes; achenes small, obliquely ovoid, black, shining.

The whole plant is clothed with small highly irritant hairs, the sting of which causes dermatitis and acute burning pain in the body. The effect lasts for several days and is aggravated when water is applied to the affected stung. The sting is particularly powerful during the flowering season when it produces violent sneezing, sleeplessness and fever (Chopra, 1958, 559).

The stem bark yields a strong fibre (cellulose content, 53.4%; length of ultimate cell, 8–16 mm.) used by the hill tribes of Assam for cordage and for making coarse cloth. It is inferior to rhea (*Boehmeria nivea*) and is not of any commercial importance because of the presence of stinging hairs which render fibre extraction difficult. Flowers are reported to be used in curries in N. Lakhimpur (Assam). The wood is used as fuel [Carter & Carter, *Rec. bot. Surv. India*, 1921, **6**(9), 367; Burkill, II, 1318].

The juice of the root is reported to be used in chronic fevers in N. Lakhimpur. Roots and leaves are applied to swellings and blind abscesses. The seeds are used medicinally in the same way as coriander (Kirt. & Basu, III, 2343; Carter & Carter, loc. cit.; Burkill, II, 1318).

L. terminalis Wight (NEPAL—*Patle sisnu*) is an erect herb, 0.6–1.2 m. high, with orbicular to oblong-ovate or lanceolate leaves, found in sub-tropical Himalayas from Kumaon eastwards, N. Bengal, Naga and Aka hills in Assam, Nilgiri and Palni hills and Kerala, at altitudes of 1,200–2,700 m. Young shoots are eaten after boiling. The stinging hairs cause dermatitis (Cowan & Cowan, 128; Chopra, 1958, 559).

Larch—*see* **Larix**

Lard—*see* **Fats and Oils**

LARIX Mill. (*Pinaceae*)

D.E.P., IV, 588; Fl. Br. Ind., V, 655.

A small genus of trees found in the colder regions of the northern hemisphere. One species occurs in India.

L. griffithiana Carr. syn. *L. griffithii* Hook. f. & Thoms. (HIMALAYAN LARCH, SIKKIM LARCH; NEPAL—*Boargasella, binyi*; LEPCHA—*Sah, saar*) is a deciduous, monoecious pyramidal tree, usually up to 18 m. in height, found in the Himalayas from eastern Nepal to Bhutan at altitudes of 2,400–3,600 m. Bark thick, brown; branches spreading and pendulous; leaves light green, linear, spirally arranged on long shoots and in fascicles on dwarf shoots; male flower c. 1.0 cm. long, female flower ovoid; cone violet purple during growth, becoming cylindrical, 5–10 cm. long; seeds oblong, winged.

The tree occurs either in pure forests or more often mixed with other conifers. It inhabits deep valleys, but prefers dry rocky ancient moraines and grassy slopes where drainage is good. The growth is slow (mean annual girth increment, 0.29 in.). The wood (wt., 32 lb./cu. ft.) is durable. It splits well and is reported to be suitable for cheap grade pencils (Dallimore & Jackson, 358–59; Troup, III, 1157; Gamble, 721; Rehman & Ishaq, *Indian For. Leafl.*, No. 66, 1945, 7).

Larkspur—*see* **Delphinium**

LASIA Lour. (*Araceae*)

A very small genus of perennial herbs distributed in the Indo-Malayan region. One species occurs in India.

L. spinosa Thw. syn. *L. heterophylla* Schott

D.E.P., IV, 589; Fl. Br. Ind., VI, 550; Kirt. & Basu, Pl. 1007.

BENG.—*Kanta kachu*; TEL.—*Mulasari, kanta kachoramu*.

SANTAL—*Kanta saru*; MUNDARI—*Janum saru*.

A stout prickly herb, 60 cm. high, with thick creeping rhizome, found along marshy places, muddy streams and swampy ground in tropical Sikkim Himalayas, Assam, West Bengal, Bihar, Orissa and southwards to Ceylon. Leaves long-petioled, 15–45 cm. long, hastate, sagittate or pinnatifid; spadix short, cylindrical, claret-coloured, densely packed with pink flowers; fruit an oblong or capitate syncarp of obpyramidal, 6-sided, muricate berries; seeds compressed, rugose.

All parts of the plant, particularly tender leaves, are used as vegetables with boiled rice. The fruit, though fibrous, is eaten (van Buuren, *Trop. Agriculturist*, 1917, **49**, 261; Burkill, II, 1319).

The plant is recommended for colic, rheumatism and intestinal diseases. Rootstock and fruits are used for affections of the throat. The juice of the rootstock is given as a remedy for piles in Ceylon. Leaves are used for stomach ache and other pains. The petioles are ground and given to cattle in throat complaints.

The spadix is reported to contain hydrocyanic acid [*J. sci. Res. Indonesia*, 1952, **1** (suppl.), 19; Kirt. & Basu, IV, 2624; Haines, V, 860; van Buuren, loc. cit.; Burkill, II, 1319; Wehmer, I, 136].

LASIOSIPHON Fresen. (*Thymelaeaceae*)

A genus of shrubs or small trees distributed chiefly in tropical Africa and a few in Madagascar, India and Ceylon. One species occurs in India.

L. eriocephalus Decne.

D.E.P., IV, 589; C.P., 546; Fl. Br. Ind., V, 197; Fyson, II, Pl. 441.

MAR.—*Ramita, rametta, rami*; TAM.—*Nachinaar*; KAN.—*Ennjariga, mukute*; MAL.—*Nangu, nanca.*

A small tree or much-branched shrub, 1.8–3.0 m. high, found in open forests on the hills of Deccan and western ghats from Konkan southwards to Kerala, Nilgiri, Palni and Tinnevelly hills ascending to altitudes of 1,200–2,100 m. Bark grey, rather smooth, inner bark fibrous; leaves subsessile, oblong-lanceolate, acute; flowers small, yellow, in dense terminal globose heads; fruit ellipsoid-oblong, 1.0–1.3 m. long, pointed, enclosed in perianth.

The stem bark is used by hill tribes for tying bundles. It yields a fibre and has been tried as a raw material for paper manufacture. Digestion in a kier (pressure, 25 lb./sq. in.; cooking period, 2.5 hr.; alkali conc., 10.9%; bath ratio, 1:30) gave a pulp containing 76.3% α-cellulose and 5.1% ash in 37% yields: the whiteness of the pulp was 77.6%. Fine bleached paper has been produced from the pulp on a cottage scale (Cooke, II, 542; Ahmad & Karnik, *J. sci. industr. Res.*, 1943–44, **2**, 275; Gondhalekar, *Poona agric. Coll. Mag.*, 1952–53, **43**, 15).

The bark and leaves of the plant are acrid and poisonous. They are used as fish poison; the fishes do not die but float along the stream in a stunned condition. The bark contains a vesicant resin. The plant causes dermatitis and its leaves are applied to swellings and contusions [Santapau, *Rec. bot. Surv. India*, 1953, **16**(1), 261; Dymock, Warden & Hooper, III, 225–26; Chopra *et al.*, 40, 47, 60; Kirt. & Basu, III, 2170].

LASIURUS Boiss. (*Gramineae*)

D.E.P., III, 242; Fl. Br. Ind., VII, 161; Blatter & McCann, 36, Pl. 25.

A small genus of perennial grasses found in the tropics and sub-tropics, of which one species, *L. hirsutus* (Forsk.) Boiss. syn. *Elionurus hirsutus* Munro ex Benth. (PUNJAB—*Sin, sewan, shewar*; RAJASTHAN—*Shinwan, siwan, gawan*), occurs in the sandy areas of Punjab and Rajasthan. Stem 30–60 cm. high, ascending from a branching, stout and rigid base; leaves narrow, finely acuminate, coriaceous, with white sheaths; spike solitary, stout, 5–10 cm. long, silvery silky.

The grass is nutritious and affords good grazing when young; it keeps well for ten years when stacked. Mature grass is coarse and thick and used for thatching purposes. It is used as fodder for elephants, camels, cattle and sheep. The seeds are used as food in admixture with *bajra*. The roots yield a fibre used for weavers' brushes (Dalziel, 530).

LATANIA Comm. (*Palmae*)

Blatter, 167, Pl. XXXVI.

A very small genus of tall, fan-leaved palms, native of Madagascar and Mauritius Islands. Two or three species are grown in Indian gardens as ornaments.

L. commersonii J. F. Gmelin syn. *L. rubra* Jacq. (COMMERSON'S LATANIA; THE RED LATAN PALM) is a handsome dioecious palm, c. 12 m. high. Stem smooth and slender, red; leaves borne on bright crimson stalks 1.2–1.8 m. long, bright green with red veins; fruit globose, 3.7–5 cm. diam. with a single seed.

The fruits of the palm are reported to be eaten, though they have a disagreeable flavour. Leaves are used for thatching and for making hats. The wood may be used for walking sticks (Firminger, 307; Gopalaswamiengar, 373; Burkill, II, 1321).

L. verschaffeltii Lem., a palm somewhat similar to *L. commersonii*, bears yellow-veined, pale green leaves; petioles slender, smooth, 0.6–1.2 m. long, densely tomentose. This palm is of slow growth, but stands exposure well. The wood, which is beautifully marked, is used for walking sticks (Gopalaswamiengar, 374; Blatter, 173).

Laterite—*see* **Iron Ores**

LATHYRUS Linn. (*Leguminosae*)

A genus of herbs distributed chiefly in the North temperate zone; a few species are found in South America and tropical mountains. About nine species occur in India; a few exotics are cultivated in gardens.

Lathyrus spp. are grown for food, fodder, green manure and ornament. Many of them are, however, poisonous.

L. odoratus Linn. SWEET PEA

Bailey, 1947, II, 1825; III, 3284, Pl. 109.

A climbing, lightly pubescent annual, native of Sicily, commonly grown in gardens for its attractive, fragrant flowers. Leaves pinnate: leaflets usually 2, oval or oblong, 2.5–5.0 cm. long, upper leaflets modified into tendrils; flowers 1–4 in a raceme, in varying shades of white, yellow, pink, purple or blues; pods c. 5 cm. long, pubescent; seeds many, globular, grey brown.

Sweet pea is one of the most popular among annual flowers for its range of colour, beauty of form, fragrance and value as cut flowers. The plants grow well in light rich soil and in open sunny situations. Seeds are sown in September in the plains and in June–July on the hills. They require a support when they become c. 15 cm. high. Removal of withered flowers and pods enhances the period of bloom. A dwarf race (Cupid Sweet Pea), which does not climb and has several colour forms, has been evolved. It is good in pots and suitable for edging beds (Gopalaswamiengar, 441–42; Firminger, 562; Chittenden, IV, 2061).

The pigments present in the flowers are mostly anthocyanins: orange-red flowers contain pelargonidin 3-monoside and pelargonidin 3,5-dimonoside; deep red and pink flowers contain cyanidin and peonidin diglycosides: a mixture of delphinin, cyanidin and pelargonidin diglycosides are present in wine-red flowers; and violet, maroon and blue flowers contain malvidin 3,5-dimonoside and delphinidin 3,5-dimonoside. Anthoxanthins are also present. Variation in flower colours has been attributed to differences in the relative amounts of anthocyanin and anthoxanthin copigment; in some cases, colour variation is associated with the degree of oxidation of anthocyanins in flowers and leucoanthocyanins in seed coats (Ponniah & Seshadri, *J. sci. industr. Res.*, 1953, **12B**, 605; Robinson & Robinson, *Biochem. J.*, 1934, **28**, 1716; *Chem. Abstr.*, 1940, **34**, 2880).

The flowers have a sweet and delicate perfume resembling that of orange flowers and hyacinth. They contain a small amount of essential oil with an odour suggestive of methyl anthranilate. The perfume can possibly be extracted by enfleurage, but it has not been attempted. Sweet pea perfume of commerce is a synthetic product [Poucher, II, 242; Krishna & Badhwar, *J. sci. industr. Res.*, 1949, **8A**(2), suppl., 157].

Sweet pea seeds contain: total N, 5.2; protein N, 4.7; and amino N, 0.12%. They are a good source of vitamin A (*Chem. Abstr.*, 1938, **32**, 3784; 1933, **27**, 5786).

Severe skeletal deformities have been produced in rats fed on a diet containing sweet pea seeds; in some cases, reproduction failure, dissecting aneurysm of aorta, and degenerative arthritis are also reported. The symptoms are different from those of lathyrism in human beings. The toxic principle has been identified as β-(γ-L-glutamyl)-aminopropionitrile ($C_8H_{13}O_3N_3$, m.p. 193-94° decomp.) which is present in concentrations varying from 58 to 160 mg./100 g. according to variety. It is readily extracted with cold water or 30% alcohol; the extracted meal is non-toxic (Lewis *et al.*, *J. Nutr.*, 1948, **36**, 537; Subrahmanyan *et al.*, *Food Sci.*, 1957, **6**, 156; Schilling & Strong, *J. Amer. chem. Soc.*, 1954, **76**, 2848; Garbutt & Strong, *J. agric. Fd Chem.*, 1957, **5**, 367).

L. sativus Linn. CHICKLING VETCH, GRASS PEA

D.E.P., IV, 590; C.P., 703; Fl. Br. Ind., II, 179; Kirt. & Basu, Pl. 314A.

HINDI—*Khesari, latri, tiuri, kassar*; BENG.—*Khesari*; MAR.—*Lakh*; GUJ.—*Lang*; ORIYA—*Khesra*.

ASSAM—*Khesari, teora*; BIHAR—*Kesari, kansari, batura*; PUNJAB—*Kisari, chural, karas, karil*; NEPAL—*Kesari*.

A much-branched sub-erect annual found throughout India as a weed and cultivated for pulse and fodder, especially in northern, central and western India up to an altitude of 1,200 m. Stem up to 1.2 m. long; leaves pinnately compound: leaflets usually 2, linear-lanceolate, upper leaflets modified into tendrils; flowers solitary, axillary, reddish purple, blue or white; pods oblong, 2.5–3.7 cm. long, flat, slightly curved, dorsally 2-winged; seeds 4–5 in a pod, facetted, greyish brown or yellowish, usually spotted or mottled, somewhat smaller than peas.

The plant is considered native of southern Europe and western Asia and is grown in India, Iran, Middle East, southern Europe and South America. In India, it occupies 4% of the total area under pulse crops and constitutes c. 3% of the total pulse production. About 4 million acres, producing nearly 0.5 million tons of seed, were under this crop in 1956-57. The main producing areas are: Patna, Gaya, Shahabad, Muzaffarpur, Darbhanga and Monghyr districts in Bihar, Drug, Raipur, Bilaspur and Balaghat districts in Mahakosal region (Madhya Pradesh), Midnapur, Murshidabad, Hooghly and 24-Parganas in West Bengal and Bhandara, Chanda and Parbhani districts in Maharashtra. The crop is cultivated to small extent

TABLE 1—ACREAGE AND PRODUCTION OF KHESARI*

State	Area (thousand acres)				Production (thousand tons)			
	1956 57	1957 58	1958 59	1959 60	1956 57	1957 58	1958-59	1959 60
Madhya Pradesh	1,501	1,125	1,478	1,468	154	122	134	246
Bihar**	1,762	1,309	2,160	2,202	232	205	406	344
West Bengal	357	256	363	498	65	46	60	90
Bombay	412	407	330†	337†	50	48	38†	35†
Assam	17	17	18	18	3	3	3	2

* Data from Directorate of Econ. & Statist., Minist. Food & Agric., Govt. India.
**Data from the Directorate of Statist., Bihar.
† Data for Maharashtra only.

in the eastern districts of U.P., Brahmaputra valley in Assam and riverine tracts of Punjab. An estimate of the acreage and production of *khesari* in India is given in Table 1 [Whyte *et al.*, 282; Mehta, *Agric. Anim. Husb., Uttar Pradesh*, 1955 56, **6**(2-3), 3].

FIG. 19. LATHYRUS SATIVUS—FLOWERING AND FRUITING BRANCH

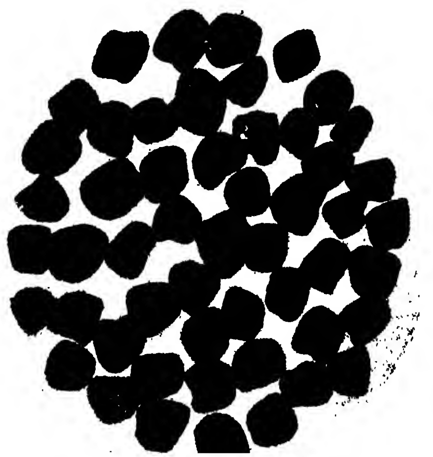
Khesari can be grown on almost all types of soil. It is commonly cultivated on heavy, clay soils; deep retentive black soil is considered to be the best. The plant is hardy, amenable to easy cultivation and grows even on land subject to drought, excessive rain or flood. Much of the land considered unfit for wheat, cotton, rice and the more popular pulses may be sown with *khesari*. It may be sown pure or mixed; it is often sown with standing rice crop. In Bihar, it comes up self-sown; in the Deccan, it is chiefly a second crop after rice.

L. sativus is cultivated as a cold weather crop and sown in September October or even later. The seed rate varies from 12–50 lb. per acre according to the method of cultivation followed. Seeds may be sown broadcast or in furrows *c.* 3 cm. apart. In a well-prepared field the crop comes up as a thick close mass over the whole surface and smothers weeds. In the case of unheeded or self-sown crops, however, a number of leguminous weeds, e.g. *Vicia sativa* Linn., *V. angustifolia* Linn. syn. *V. sativa* var. *angustifolia* Baker, *V. hirsuta* S.F. Gray, *Lathyrus aphaca* Linn. and *L. sphaericus* Ritz., come up along with the crop. The weeds are easily differentiated from *L. sativus*, but unless eliminated when comparatively young, they form dense intertwined masses and separation from *L. sativus* becomes difficult. For this reason the pulse available in the bazaar is quite often mixed with weed seeds. The crop ripens in 4–5 months and is harvested as soon as leaves begin to turn yellow and pods are not fully ripe; fully ripe pods dehisce and result in loss of seeds. The crop may be reaped with a sickle or plants may be uprooted. Harvested crop is allowed to dry in heaps in the field for a week and then threshed and winnowed. The yield is proportional to the quantity of seed sown. An average crop at a seed rate of 40 lb. per acre yields 925 lb. of pulse

and 1,323 lb. of fodder per acre ; at a seed rate of 14 lb. in mixed cultivation, the yield per acre is 300 lb. of pulse and 400 lb. of straw. In a well-grown crop the yields of pulse and fodder are about equal [Mollison, III, 78-80 ; Mukerji, 204 ; Hall, 151 ; Mehta, *Agric. Anim. Husb., Uttar Pradesh,* 1955-56, **6**(2-3), 15 ; Haines, III, 250 ; Ambekar, *Bull. Dep. Agric. Bombay*, No. 146, 1927, 40 ; Anderson *et al., Indian J. med. Res.*, 1924-25, **12,** 617].

The recorded fungal diseases of *khesari* include: mildew (*Oidium erysiphoides* Fr. and *Perenospora lathyripalustris* Gaumann), rusts [*Uromyces pisi* (Pers.) Wint. and *U. fabae* (Pers.) de Bary] and wilt (*Fusarium orthoceras* var. *lathyri*). The last mentioned disease is reported to cause serious loss in Broach district (Gujarat). A resistant strain, *Indore T. 2-12*, which is earlier and yields more than the local type has been released for cultivation [*Indian J. agric. Sci.*, 1950, **20,** 107 ; Saksena, *Sci. & Cult.*, 1956-57, **22,** 337 ; *Biol. Abstr.*, 1949, **23,** 230 ; Bhide & Dhande, *Farmer*, 1952, **3**(6), 35].

Indian *khesari* plants have been roughly classified on the basis of the colour of flowers, markings on pods and size and colour of seeds. About 56 types of *khesari* have been differentiated in bazaar samples. They are of small, medium or large size in combinations of grey, black or mottled colour. Seeds from crops raised in rice fields are usually smaller than those grown in rich dry soils ordinarily devoted to wheat. The smaller form is known as *lakhori* (wt., 77-108 g./100 seeds) and the larger form as *lakh* (wt., 110-245 g./100 seeds) [Howard *et al., Mem. Dep. Agric. India, Bot.*, 1928, **15**(2), 51].



I.A.R.I., New Delhi

FIG. 20. LATHYRUS SATIVUS—SEEDS

Khesari seeds are used as an article of diet by the poor in times of famine. They are made into *chapaties*, paste balls and curry or boiled and eaten like a pulse. At some places, the seeds are dehusked and parched before use. Being cheap and easy to cultivate, *khesari* is used as an adulterant of other pulses. Mixed with oil cakes and salts, the seeds are used as nutritious feed for cattle. The seeds are also used in homeopathy. They may be used also as a source of protein for the preparation of plywood adhesives (Chopra *et al.*, 381 ; Jacoby, *Indian med. Gaz.*, 1947, **82,** 122 ; Howard *et al.*, loc. cit. ; Steinmetz, II, 266 ; Narayanamurti & Chimma, *Indian For. Leafl.*, No. 119, 1949).

Analysis of seeds gave the following values: moisture, 10.0 ; protein, 28.2 ; fat (ether extr.), 0.6 ; carbohydrates, 58.2 ; and mineral matter, 3.0%. The seeds contain starch (34.8%), sucrose (1.5%), pentosans (6.8%), phytin (3.6%), lignin (1.5%), stachyose, raffinose and pectins. The starch consists of amylose (30.3%) and amylopectin (69.7%) (*Hlth Bull.*, No. 23, 1951, 30 ; *Chem. Abstr.*, 1951, **45,** 3041 ; 1952, **46,** 2705 ; 1947, **41,** 3547 ; Patel *et al., Sci. & Cult.*, 1958-59, **24,** 291).

Khesari contains albumin (6.64%), prolamine (1.49%), globulin (13.30%) and glutelin (3.75%). The nitrogen distribution in the albumin (N, 16.38 ; and S, 0.88%) is as follows: sol. humin N, 1.03 ; insol. humin N, 1.66 ; amide N, 7.65 ; total basic N, 29.25 ; and non-basic N, 60.44% of total nitrogen. The distribution of nitrogen in the globulin (N, 16.8 ; P, 0.1 ; and S, 0.44%) is as follows: sol. humin N, 0.27 ; insol. humin N, 0.27 ; amide N, 9.56 ; total basic N (arginine, 14.92 ; histidine, 9.93 ; cystine, 0.17 ; lysine, 10.68%), 35.70 ; and non-basic N, 52.16% of total nitrogen. Xanthine, guanine and free arginine, glutamic acid, alanine, valine and leucine are present (*Chem. Abstr.*, 1947, **41,** 3547 ; Rau, *Proc. Indian Acad. Sci.*, 1934-35, **1B,** 73 ; Ganapathy *et al., Ann. Biochem.*, 1958, **18,** 157).

At 10% level of protein intake, *khesari* proteins have high digestibility (90%) but low biological value (50%). The essential amino acids present in the proteins are (expressed in g./16 g.N): arginine (7.85), histidine (2.51), leucine (6.57), isoleucine (6.59), lysine (6.94), methionine (0.38), phenylalanine (4.14), threonine (2.34), tryptophan (0.40) and valine (4.68). The proteins are deficient in methionine and tryptophan. Autoclaving of seeds and supplementation with methionine greatly enhance their nutritive value (Basu *et al., Indian J. med. Res.*, 1936-37, **24,** 1001 ;

Ramachandran & Phansalkar, ibid., 1956, **44,** 50; Esh & Som, *Indian J. Physiol.*, 1952, **6,** 61).

The vitamins present in the seeds are: carotene (as vitamin A), 200 i.u.; thiamine, 0.21; riboflavin, 0.16; nicotinic acid, 3.3; biotin, 7.5; pantothenic acid, 2.6; folic acid, 100; pyridoxine, 0.65; inositol, 140; ascorbic acid, 3.1; and dehydro-ascorbic acid, 0.2 mg./100 g. Germinated seeds show considerable increase in vitamins, except folic acid, biotin and pyridoxine, which diminish during germination (*Hlth Bull.*, No. 23, 1951, 30; Chattopadhyay *et al.*, *Indian Pharm.*, 1949–50, **5,** 21; Nandi & Banerjee, ibid., 1949–50, **5,** 63, 202; Banerjee *et al.*, *Food Res.*, 1954, **19,** 134; 1955, **20,** 545).

The lipids of the plant are composed of fat (60%) and phosphatides (40%). Extraction of seeds with ether gives a viscous oil with a strong stinging odour and characteristic taste; it has the following constants: sp. gr.$^{20°}$, 0.9285; $n_D^{20°}$, 1.4768; acid val., 44.99; sap. val., 172; Hehner val., 84.05; R.M. val., 1.99; and unsapon. matter, 16.2%. Stigmasterol and a yellow pigment are present. The oil has cathartic properties but is toxic (*Chem. Abstr.*, 1952, **46,** 2705; 1951, **45,** 3041; Chakravarti *et al.*, *J. sci. industr. Res.*, 1956, **15C,** 89; De & Dutta, *Sci. & Cult.*, 1948–49, **14,** 159; Chopra, 502).

The seeds contain a rhamnoside of a flavone derivative and possibly also a lycopene. Saponins, alkaloids and a compound yielding hydrogen sulphide have been reported to be present by some authors. Cyanogenetic glucosides occur, if at all, in very small amounts (*Chem. Abstr.*, 1947, **41,** 3547; Biswas, *Sci. & Cult.*, 1943–44, **9,** 165; Wehmer, I, 571).

Analysis of seed ash (total ash in sample, 2.6–2.8%) gave the following values: phosphorus (P_2O_5), 20.80; calcium (CaO), 12.62; magnesium (MgO), 3.87; potassium (K_2O), 47.20; sodium (Na_2O), 20.35; chlorine, 3.28; and sulphur (SO_3), 3.25%. Trace elements reported to be present are: aluminium, boron, copper, iron (total, 9.97; available, 4.40 mg./100 g.), lithium, manganese, molybdenum, nickel, lead, titanium, fluorine and selenium (22.9 mg./100 g.). Germinated seeds contain higher proportion of available iron (5.53 mg./100 g.) (*Chem. Abstr.*, 1951, **45,** 3041; Singh & Banerjee, *Indian J. med. Res.*, 1955, **43,** 497; *Annu. Rep. Indian vet. Res. Inst.*, 1949–50, **43**; Rudra, *Nature, Lond.*, 1952, **170,** 124).

The leaves of the plant are eaten as pot-herb. Analysis of leaves gave the following values: moisture, 84.2; protein, 6.1; fat (ether extr.), 1.0; carbohydrates, 7.6; mineral matter, 1.1; calcium, 0.16; and phosphorus, 0.1%; iron, 7.3 mg.; and carotene (as vitamin A), 6,000 i.u./100 g. (Bressers, 44; *Hlth Bull.*, No. 23, 1951, 34).

Khesari crop is often grown for fodder; plants can be reaped and fed green or standing crop can be pastured. *Khesari* is not fit for silage but can be cured into hay under mild climatic conditions. Analysis of green plant, cut at the flowering stage gave the following values (dry basis): protein, 17.3; fibre, 36.6; fat, 4.47; ash, 6.0; phosphorus (P_2O_5), 0.51; and calcium (CaO), 1.08%. When fed alone, fresh young plants are reported to be harmful to horses; cattle, sheep and rabbits, however, consume relatively large amounts without ill effects. Analysis of hay gave the following values: moisture, 14.53; crude protein, 9.94; fat, 1.91; fibre, 36.48; N-free extr., 31.05; and ash, 6.09%; starch equivalent, 12.5 kg./100 kg. A sample of hay (ash, 8.0%) contained: phosphorus (P_2O_5), 0.34; and calcium (CaO), 0.96%. The crop is also valued as green manure; at a seed rate of 60 lb. an acre, it is said to add about 55 lb. of nitrogen [Hall, 151; Khan, *Indian Fmg, N.S.*, 1952, **53**, **2**(3), 8; *Chem. Abstr.*, 1934, **28,** 2426; 1938, **32,** 6352].

Lathyrism—People in scarcity areas consuming *khesari* as the principal article of diet for months, are known to be affected by a paralytic disease, known as lathyrism. Occasional use of the pulse, however, appears to be harmless. Both human beings and livestock are susceptible to lathyrism and severe epidemics have been reported in the past from Bihar, Madhya Pradesh and some eastern districts of U.P. Lathyrism manifests itself by partial or complete paralysis of the lower limbs and is characterized by degenerative changes in the spinal cord. The onset of the disease is often sudden and it usually occurs during the monsoon. In the early stages the patient finds difficulty in walking; the gait becomes jerky and the legs may have to be crossed while walking. Thigh and calf muscles become rigid and lower limbs are paralysed. There is no atrophy or degeneration of muscles as such and the upper part of the body generally remains unaffected. The cerebrospinal fluid shows no abnormalities of pressure, cell count and albumin content. Blood pressure, heart and lungs remain normal. Lathyrism is more prevalent in young males. In the case of horses, not only the limbs but also the muscles of larynx are paralysed and the animal suffers from acute suffocation. Paroxysms usually pass off but may, sometimes, prove fatal. In human beings the lesions on the spinal cord

are permanent, indicating permanent destruction of tract : in animals, however, the disease is transient suggesting ischaemia and interference with function, rather than permanent destruction of affected cord (Modi, 658 ; Chopra *et al.*, 382–86 ; Jacoby, *Indian med. Gaz.*, 1947, **82,** 53 ; Acton & Chopra, ibid., 1922, **57,** 412 ; Forsyth, *Bull. Minist. Agric., Lond.*, No. 161, 1954, 39).

Although epidemics of lathyrism have invariably occurred in *khesari* producing areas and there is experimental and circumstantial evidence ascribing lathyrism to the continuous use of *khesari*, the poisonous effects have sometimes been attributed to individual idiosyncrasies. *Lakhori* seeds are generally regarded to be harmless but *Lakh* seeds are considered poisonous. Most of the investigations seem to have been carried out on specimens which are botanically impure.

The factors responsible for lathyrism in man and animals have not been identified with any certainty. Early reports, most of which have been shown to be untenable, ascribed the ill effects variously to the presence in the pulse of an alkaline volatile liquid, toxic alkaloids, a water soluble toxic amine or organic phytates ; contamination of *khesari* with *Vicia* sp. which contains poisonous alkaloids and deficiency of essential amino acids in *khesari* proteins have also been considered responsible for the observed effects. It has been recently reported that the presence of selenium in *khesari* which interferes with methionine metabolism, is the cause of lathyrism. It has been suggested that the toxic effect is due to a pathogenic fungus which grows on the pulse during wet storage. Lathyrism has also been regarded as a virus infection. But none of the explanations offered appears to be conclusive (Subrahmanyan *et al.*, *Food Sci.*, 1957, **6,** 156 ; Chopra *et al.*, 383–84 ; U.S.D., 1955, 1733 ; Rudra, *J. Asiat. Soc. Sci.*, 1952, **18,** 141 ; Jacoby, *Indian med. Gaz.*, 1947, **82,** 122 ; *Chem. Abstr.*, 1934, **28,** 5536 ; 1950, **44,** 4100).

No effective remedy has been found for lathyrism so far. Prostigmin gave only slight relief from pain in earlier stages. The disease is checked by putting the patient on a nutritive diet and discontinuing the use of *khesari*. The seeds are said to lose toxicity, if soaked in water for at least 24 hours before cooking. The pulse is also reported to be harmless when consumed along with flowers of *Madhuca indica* J. F. Gmel. Under the Prevention of Food Adulteration Rules, Minist. Hlth, Govt. India, 1955 (amended up to 1959), the sale of *khesari* and *khesari* products has been prohibited (Jacoby, *Indian med. Gaz.*, 1947, **82,** 53 ; *Field Crop Abstr.*, 1952, **5,** 86).

L. aphaca Linn. (Yellow Vetchling ; Hindi – *Janglimatar* ; Beng.—*Jangli matar, masur-channa* ; Nepal—*Kaibu* ; Punjab—*Gagla, rewan, rewari*) is a much-branched trailing annual met with as a weed in North India, ascending in the Himalayas up to an altitude of 2,100 m., in Bengal, Madhya Pradesh and Nilgiris in the south. Stipules leafy ; leaves modified into tendrils ; flowers yellow, axillary ; pods sickle shaped with 4–6 seeds.

The herb is used as a fodder and is sometimes cultivated for this purpose. Young seeds are harmless but ripe ones, if abundantly eaten, produce narcotic effects. Flowers are reported to possess resolvent properties. This herb has also been considered to be one of the possible causes of lathyrism (Kirt. & Basu, I, 771 ; Chopra *et al.*, 386).

L. imphalensis Watt is a herb recorded from Manipur at 1,200 m. It is locally used as fodder.

L. pratensis Linn. (Meadow Vetchling) is a finely pubescent herb with racemes of yellow flowers and 5–10 seeded compressed pods, distributed in western Himalayas at altitudes of 1,800–2,400 m. The seeds are used in Spain as a resolvent (Kirt. & Basu, I, 772).

L. sphaericus Retz. is a much-branched trailing annual with reddish flowers and linear, many seeded pods, found in the plains of North India and in western Himalayas up to an altitude of 1,650 m. The plant is poisonous and its seeds often get mixed with *khesari* in fields (Singh, *Bull. Indian Coun. agric. Res.*, No. 76, 1956, 34).

L. tingitanus Linn. (Tangier Pea) is a climbing annual, native of North Africa, cultivated for its brilliant scarlet purple flowers. It is useful as fodder and green manure ; its introduction into India has been suggested. The seeds are toxic causing essentially the same symptoms in rats as sweet pea (Hector, II, 657 ; Chakravarty, *Sci. & Cult.*, 1955–56, **21,** 242 ; Subrahmanyan *et al.*, loc. cit.).

LATIPES Kunth (*Gramineae*)

Fl. Br. Ind., VII, 97 ; Blatter & McCann, 218, Pl. 145.

A monotypic genus, comprising the species *L. senegalensis* Kunth, a small perennial grass, with wiry, creeping stems, 7.5–25.0 cm. long and many erect or spreading leafy branches and racemes 5–15 cm long, found in Rajasthan, Sind and Baluchistan, extending to Arabia and Africa. It is a good fodder in

subdesert regions. The seeds are reported to be used as food in Africa (Blatter & Hallberg, *J. Bombay nat. Hist. Soc.*, 1918–21, **26**, 979; Dalziel, 530).

LAUNAEA Cass. (*Compositae*)

D.E.P., IV, 594; Fl. Br. Ind., III, 414.

A genus of glabrous herbs, often with yellow juice, distributed in tropical and sub-tropical regions. Seven species are found in India.

L. aspleniifolia Hook. f. (HINDI—*Titlia*; BENG.—*Tik-chana*; SANTAL—*Birmalla*) is a biennial or perennial herb with long slender roots, narrowly obovate, lobed and toothed leaves and yellow paniculate flower heads, found throughout the plains of northern India and Bengal extending southwards to Andhra; it is also met with in the Andamans. The root in combination with other drugs is used as a galactagogue by the Santals (Kirt. & Basu, II, 1446).

L. glomerata Hook. f. is a glaucescent herb with lobed, pinnatifid or runcinate leaves, yellow flower heads and conspicuously winged fruit. It has been recorded from Kathiawar, Kutch and Mt. Abu. A decoction of the herb mixed with wheat meal is applied as a poultice to sore eyes (Kirt. & Basu, II, 1449).

L. mucronata (Forsk.) Muschler, syn. *L. chondrilloides* Hook. f. (RAJASTHAN—*Dhud phad*) is a herb resembling *L. aspleniifolia* found in western India. It is also credited with galactagogue properties. A decoction of the herb is administered in constipation (Kirt. & Basu, II, 1448; Blatter & Hallberg, *J. Bombay nat. Hist. Soc.*, 1918–21, **26**, 538).

L. nudicaulis Hook. f. (PUNJAB—*Batthal, dudhlak*; RAJASTHAN—*Akria, ban gobi, jangli gobi*; BOMBAY—*Pathari*) is a decumbent herb with a tuft of simple or branched flowering stems arising from a rosette of sessile, lobed or runcinate, sharply toothed leaves (5–25 cm. × 2.5–7.5 cm.) and bearing yellowish flower heads either solitary or in clusters. It occurs as a weed more or less throughout the plains of India, ascending up to an altitude of 2,400 m. in the Himalayas. The plant is used as fodder for goats. It is also used in the preparation of a cooling sherbet. Leaves are used locally in curries [Santapau, *Rec. bot. Surv. India*, 1953, **16**(1), 155; Kirt. & Basu, II, 1447; Sabnis, *J. Bombay nat. Hist. Soc.*, 1940–41, **42**, 376].

L. sarmentosa (Willd.) Alston syn. *L. pinnatifida* Cass. is a procumbent herb with flagelliform stems arising from a tuft of radical, oblong, sinuate or runcinate, toothed leaves and bearing yellow flower heads. It is found along sandy sea beaches and is considered useful as a sand binder. It is reported to possess tonic, soporific, diuretic and aperient properties and used as a substitute for Taraxacum. Leaves are eaten during famine. The herb is fed to buffaloes as a galactagogue [Kirt. & Basu, II, 1447–48; Chopra, 1958, 512; Caius, *J. Bombay nat. Hist. Soc.*, 1939–40, **41**, 850; Gammie, *Rec. bot. Surv. India*, 1902, **2**(2), 183].

FIG. 21. LAUNAEA NUDICAULIS—FLOWERING PLANT

Laurel, Alexandrian — *see* **Calophyllum**

Laurel Nut — *see* **Calophyllum**

Laurel, True — *see* **Laurus**

LAURENTIA Adans. (*Campanulaceae*)

Santapau, *J. Bombay nat. Hist. Soc.*, 1955–56, **53**, 156.

A genus of herbs distributed in North and South

FIG. 22. LAURENTIA LONGIFLORA—FLOWERING PLANT

America, Mediterranean region and Africa, and introduced elsewhere. One species has been recorded in India.

L. longiflora (Linn.) Endl. syn. *Lobelia longiflora* Linn. *Isotoma longiflora* Presl. is a herb up to 50 cm. in height, with sub-sessile lanceolate, dentate leaves and rather attractive, sweet scented or inodorous, white, solitary, axillary flowers. It is found as a weed in waste lands in some parts of Bombay: it is sometimes grown in gardens for ornament.

The plant is poisonous. When taken internally it causes violent purgation which may prove lethal. The juice of the plant produces burning inflammation on contact with eyes or lips. The plant is said to be particularly harmful to horses. An alkaloid [m.p. 125°: $[\alpha]$, −3°], similar to, but not identical with lobeline has been isolated from the plant; it acts on respiration by way of chemoceptors of the carotid body, on blood pressure by way of spinal neurones and by discharge of adrenaline. Eradication of the weed before it spreads has been recommended (*Chem. Abstr.*, 1948, **42**, 1350).

LAURUS Linn. (*Lauraceae*)

Bailey, 1947, II, 1827.

A small genus of trees distributed chiefly in the Mediterranean region. *L. nobilis* Linn. (SWEET BAY, TRUE LAUREL), a small evergreen hardy tree with stiff narrow fragrant leaves, is widely cultivated in Europe and America for ornament. It is sometimes grown in Indian gardens but does not seem to thrive well.

Sweet Bay is propagated by cuttings or by seed and is often grown in tubs. The plants lend themselves to decorous trimming to almost any shape—cone, pyramid, globe, etc. (Bailey, 1947, II, 1827; Firminger, 381).

Dried berries of the tree, commonly called Bay Berries, have been imported into India for medicinal use. The berry is ovoid (c. 1.5 cm. long), black, coarsely wrinkled and contains a single seed. Both leaves and fruits possess aromatic, stimulant and narcotic properties and were formerly employed for hysteria, amenorrhoea and flatulent colic. They are rarely ever used internally at the present time. Externally, however, commercial Oil of Laurel Berry is sometimes applied as a stimulant in sprains, but its principal use is in veterinary medicine. The leaves are employed as a condiment and flavouring agent in food and confectionery (Nadkarni, I, 729; Bentley & Trimen, III, 221).

The berry (pericarp, 30%; seed, 70%) yields 20-34% of an aromatic fat used to some extent in pharmacy, veterinary practice and perfumery. Commercial fat is obtained from the whole berry by pressing or by boiling with water and skimming off the separated fat. The fat (m.p. 30–34°) is green in colour and has the following characteristics: sp. gr.$^{25°}_{25°}$, 0.921–0.941; $n^{40°}_{D}$, 1.460-1.465; acid val., 5-34; sap. val., 188-216; iod. val., 75–99; thiocyanogen val., 55.8; R.M. val., .5-3.2; Polenske val., 2.8; and unsapon. matter (phytosterol, melissyl alcohol, a hydrocarbon and an unsaturated oily substance), 1–6%. The mixed fatty acids contain: lauric, 30-35; palmitic, 10-11; oleic, 33-40; and linoleic, 18–32% (Eckey, 415–18; Thorpe, VII, 197).

Fresh terminal branchlets and leaves, on steam-distillation, yield 0.5% of a volatile oil with a characteristic sweet and spicy odour, somewhat suggestive of cajuput oil. It has the following characteristics:

sp. gr.$^{15°}$, 0.910–0.944 ; $[\alpha]$, −4.7° to −21.7° ; $n^{20°}$, 1.460–1.477 ; acid val., up to 3.0 ; ester val., 21.0–55.0 (after acetylation, 36.0–96.0) : sol. in 1–3 vol. of 80% alcohol. The constituents identified in the oil are: cineole (c. 50%), eugenol, geraniol, α- and β-pinenes, α-phellandrene, *l*-linalool, *l*-α-terpineol, a sesquiterpene, esters (mainly acetates) and small amount of free fatty acids (Guenther, IV, 204–06).

Laurel wood resembles walnut wood in grain and colour and is suitable for decorative cabinet work (Howard, 65).

LAVANDULA Linn. (*Labiatae*)

A small genus of perennial aromatic herbs, subshrubs or shrubs confined to the North temperate and tropical regions of the Old World. Two species occur in India.

Three species of *Lavandula* are extensively utilized in Europe and the Mediterranean region for extracting essential oils, known in commerce as Lavender Oil, Spike Lavender Oil and Lavandin Oil. These are: *L. angustifolia* Mill. (True Lavender), *L. latifolia* Medic. (Spike Lavender) and *L. hybrida* Reverchon (Lavandin), a hybrid between true lavender and spike lavender. *L. angustifolia* yields an oil with a refreshing and delightful fragrance. *L. latifolia* grows wild in the lower altitudes of southern France, Spain and Italy ; it yields an inferior oil. *L. hybrida* possesses the characteristics of both parent plants and yields an oil which combines the fragrance of true lavender with the camphoraceous harshness of spike lavender. Lavandin oil is attaining increasing importance in trade and is popular with perfumers and soap manufacturers. Because of the relative ease of cultivation, higher yield of oil per acre and heavy demand for the oil, the total production of lavandin oil has gone up with a marked fall in the production of lavender oil ; many growers have now switched over from lavender to lavandin cultivation. The characteristics of the three oils are summarized in Table 1. None of the oil-yielding species occurs in India. Lavender oil is imported (Table 2) (Chaytor, *J. Linn. Soc., Bot.*, 1937–38, **51**, 153 ; Guenther, III, 503–04, 512, 492 ; Guenther, *Econ. Bot.*, 1954, **8**, 166).

L. bipinnata Kuntze syn. *L. burmanni* Benth.

D.E.P., IV, 595 ; Fl. Br. Ind., IV, 631 ; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 64.

Guj. –*Sarpnocharo, aasmanifalgoto.*

Bombay– *Ghodeghui, gorea.*

A stout or slender erect herb, 0.6–1.0 m. high, found in Bihar, Chota Nagpur, Orissa, Madhya Pradesh, Rajasthan, Saurashtra, Deccan and Konkan southwards to Kerala. Leaves sessile or nearly so, pinnatipartite or deeply pinnatisect : segments linear, entire, cut or toothed ; flowers small, blue or white, fragrant, in solitary or panicled spikes ; nutlets minute, oblong-ellipsoid, black, smooth, mucilaginous when wet. Two varieties, viz. var. *rothiana* Kuntze and var. *intermedia* Kuntze, are reported to occur. The plant flowers in October–November.

The plant is aromatic. Both flowers and leaves yield essential oils, the former, a red oil with peppermint-like aroma and the latter, a yellow oil which resembles lemongrass oil in odour. The characteristics of the oils are as follows: *flower oil* –sp. gr.$^{21.5°}_{15°}$, 0.923 ; $n^{25°}_{D}$, 1.4683 ; sap. val., 149.5 ; acet. val., 199 ; and sol. in 28 vol. of 70% alcohol; *leaf oil* –sp. gr.$^{26.75°}_{15°}$, 0.895 ; $[\alpha]_D$, −0.87° ; $n^{28.5°}_{D}$, 1.4822 ; sap. val., 44.25 ;

TABLE 1—CHARACTERISTICS OF DIFFERENT LAVENDER OILS*

	Lavender oil: French	Lavender oil: English	Spike lavender oil	Lavandin oil
Sp. gr.$^{15°}_{15°}$	0.880–0.896	0.882–0.907 (at 15.5°)	0.899–0.911	0.886–0.896
$[\alpha]$	−3° to −11°	−5° to −11° (at 20°)	−7.4° to +1.2°	−2.9° to −5.4° (at 25°)
$n^{20°}$	1.4580–1.4640	1.4630–1.4730	1.4624–1.4679	1.4616–1.4640
Acid val.	..	0–3.0	..	..
Ester content (as linalyl acetate), %	30–40 (or more)	8.0–18.0	1.8–3.3	19.6–26.1
Solubility in 70% alcohol	Sol. in 2–3 vol., or more	Not completely sol. in 10 vol., or sol. with opalescence	Sol. in 3–4.5 vol. of 65% alcohol, clear to opalescent with more	Sol. in 2–2.5 vol., clear to opalescent with more

* Guenther, III, 461, 483, 497, 510.

acet. val., 141.4 ; and sol. in 2 vol. of 70% alcohol. The flower oil is reported to contain fenchone. The oils have not been exploited commercially (Kanga, *J. Indian Inst. Sci.*, 1914–18, **1,** 89 ; Guenther, III, 513).

The tops of the plant are eaten by cattle. A solution or paste of the roots is used as an external application for stings and bites of poisonous animals (Burns *et al.*, *Mem. Dep. Agric. India, Bot.*, 1928, **16,** 116 ; Kirt. & Basu, III, 1974).

L. angustifolia Mill. syn. *L. officinalis* Chaix ; *L. vera* DC. ; *L. spica* Linn. TRUE LAVENDER, COMMON LAVENDER

D.E.P., IV, 596 ; Bailey, 1949, 851 ; Chaytor, *J. Linn. Soc., Bot.*, 1937–38, **51,** 172.

A hardy, much-branched low shrub, 0.3–1.2 m. in height. Leaves opposite, oblong-linear or lanceolate, tomentose ; flowers small, lavender, highly fragrant, in terminal spikes.

L. angustifolia is a native of the mountainous districts of southern Europe bordering on the western half of the Mediterranean and extending from the eastern coast of Spain to Calabria (Italy) and North Africa. It is extensively cultivated in southern France and utilized for the production of lavender oil : more than 85% of the world's oil supplies come from France. Other countries producing lavender oil are Italy, southern Russia, Hungary, England, Australia (Tasmania) and U.S.A. (Puget Sound) (Islip, *Bull. imp. Inst., Lond.*, 1948, **46,** 177 ; Guenther, *Econ. Bot.*, 1954, **8,** 166 ; Guenther, III, 441).

Attempts have been made to cultivate lavender in India. Cultivation on an experimental scale have been undertaken at several places in Kashmir (Baramula, Chattarnar, Yarikah and Srinagar) at altitudes of c. 1,500 m. and the results are promising. The climate prevailing in various hilly regions is favourable for the cultivation of lavender. There are at present 8 acres under this crop in some parts of Nilgiris [Handa *et al.*, *J. sci. industr. Res.*, 1957, **16A**(5), suppl., 12 ; Mudaliar, *Madras agric. J.*, 1953, **40,** 273 ; Menon, 18].

Lavender grows in any well-drained loam but thrives best in light and rather dry, calcareous, loose soil. It does not grow well on low and wet land. It can be grown from seed or propagated by cuttings or division. Cuttings are planted first in nursery beds and transplanted in the field, after a year, in rows 2 ft. apart, the distance between plants in the row being 12–15 in. The crop needs frequent and thorough cultivation. Plants are pruned during the first year to prevent flowering and encourage bushiness : they are ready for harvesting after three years. Flowering tops are harvested when in full bloom and distilled fresh for the production of oil. If flowers are separately required, the tops are harvested a little before flowers are fully opened ; they are tied into small bundles and hung head downwards in shade to dry : dried flowers are then separated from stems by hand (Guenther, III, 441, 443–48 ; Guenther, *Econ. Bot.*, 1954, **8,** 166 ; Sievers, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1999, 1948, 63 ; Handa *et al.*, *loc. cit.* ; Bailey, 1947, II, 1829 ; Macself, 143–44).

Oil of lavender is obtained from flowers or flowering tops mainly by steam-distillation : concretes and absolutes are prepared by extraction with volatile solvents. The water-distillation process was formerly employed for preparing the oil ; it gives an inferior oil and the yield is lower. The yield and quality of oil depend upon several factors, particularly soil and climatic conditions under which the plant is cultivated, the plant material used for distillation and the process of distillation. A yield of 0.7–0.9% (or more) is reported from flowering tops harvested from plantation crops ; the yield is barely 0.3–0.5% from wild plants. The oil obtained exclusively from flowers is of finer quality than that obtained from flowering tops ; the fraction collected in the initial stages of distillation is reported to be the most fragrant. Distilled oil is stored in the dark for 3–5 years for maturation before marketing (Guenther, III, 453–58, 442 ; U.S.D., 1955, 743 ; *Bull. Minist. Agric., Lond.*, No. 121, 1947, 13).

Lavender perfume may be extracted from the semi-dried flowering herb by benzene. A solid concrete is obtained in 1.5–2.2% yield ; it is processed further to obtain the absolute (yield, 50–60%). Both concrete and absolute are dark in colour and insoluble in dilute alcohol : they have better fixation value than distilled oil (Naves & Mazuyer, 208 ; Guenther, III, 470).

Lavender oil obtained by steam-distillation of flowering tops is a colourless, pale yellow or yellowish green liquid with a delightful fragrance and a pungent somewhat bitter, taste. Table 1 gives the characteristics of French and English lavender oils. The oil distilled from dried flowers of plants grown in Kashmir had a sp. gr.$^{15°}$ of 0.919 ; the yield was 2–4%. Lavender concrete (m.p. 32–39°) is a dark green solid with a mellow tenacious odour ; it is partly soluble in 95% alcohol. The absolute ($d^{15°}$, 0.939–0.968 ; $n^{20°}$, 1.467–1.486 ; acid val., 4.8–15.0 ; ester val.,

76–136) is a thick viscous liquid, soluble in 95% alcohol (B.P.C., 1959, 399; Naves & Mazuyer, 210–11; Guenther, III, 470; Chopra *et al.*, *J. sci. industr. Res.*, 1949, **8**, 18).

The principal constituent of lavender oil is linalyl acetate. French oils contain 30–60% acetate; English oils contain 8–18%; a sample of oil from Kashmir contained 24.8% linalyl acetate. Other constituents present in the oil are: linalool, geraniol and its esters, lavandulol, nerol, cineole, caryophyllene, coumarin (traces), limonene, β-ocimene, furfural, ethyl amyl ketone, thujone, and pinocamphone. Solvent-extracted perfume contains umbelliferone methyl ether (7-methoxy coumarin) and coumarin. English lavender oil differs from the French product in having a much lower ester content and an appreciable proportion of cineole which imparts a characteristic pungency to the oil (Guenther, III, 463–70, 483; Chopra *et al.*, loc. cit.; *Rep. essent. Oils Schimmel*, 1947–48, 34; Allen, IV, 68).

Several grades of lavender oil are available in commerce and the quality is mainly evaluated on the basis of its ester content (linalyl acetate); English oils are judged by olfactory tests. Lavender oil is frequently adulterated with glyceryl acetate, terpinyl acetate, ethyl citrate, ethyl phthalate or ethyl succinate; many oils are cut with lavandin and spike oils; adulteration with partially acetylate Ho oil is difficult to detect (Guenther, III, 442, 461–63; Poucher, I, 244–45; Parry, I, 197; Allen, IV, 69).

Oil of lavender is one of the most popular perfumes and has been in use since centuries. It is seldom used alone but serves in many blends, imparting a delightfully fresh and sweet note. It forms an important constituent of lavender water, Eau de Cologne, toilet waters in general, and high grade perfumes. The bulk of oil is utilized in scenting soap. Lavender oil is frequently used in cosmetics and for flavouring candy, cakes and similar products. Concretes and absolutes are excellent fixatives and odoriferants and are used in toilet powders, soaps, bath salts, and similar preparations (Guenther, III, 491, 470–71; Hill, 184, 447; Poucher, I, 245).

Dried flowers retain their fragrance for a long time and are used in sachets and pot pourie and for scenting chests, drawers, wardrobes and linens; they are also employed for flavouring candy, cakes and similar products. Leaves and flower buds are occasionally used for flavouring salads, dressings, fruit desserts, jelly and wine. Flowers are used in moth-repellent preparations (*Bull. Minist. Agric., Lond.*, No. 121, 1947, 12; Hill, 184, 447; Macmillan, 433; Muenscher & Rice, 87; Steinmetz, II, 268).

Lavender oil is official in B.P. (1953), U.S.P. (1955) and various other pharmacopoeias. It possesses carminative and stimulant properties. It is occasionally used to cover disagreeable odours in ointments and other preparations. It is recommended as an insect repellent (U.S.D., 1955, 744; B.P.C., 1959, 399).

The annual consumption of lavender oil in India

TABLE 2—IMPORTS OF LAVENDER OIL

	Exporting countries (Qty)					Total Qty	Total Val. (Rs.)
	France	U.K.	Netherlands	U.S.A.	Others		
1944–45 to 1948–49 (av.)	547	249	..	248	52	1,096*	182,062
1949–50 to 1953–54 (av.)	1,404	567	48	40	280	2,339*	299,516
1954–55	n.a.	n.a.	n.a.	n.a.	n.a.	3,673*	425,880
1955–56	n.a.	n.a.	n.a.	n.a.	n.a.	3,366*	491,335
1956 (April–December)	n.a.	n.a.	n.a.	n.a.	n.a.	4,312*	591,395
1957	26,210	5,591	662	..	14,735	47,198†	852,974
1958	16,432	5,912	453	..	15,312	38,109†	656,997
1959	16,926	9,567	260	..	6,189	32,942†	581,891
1960 (January–March)	6,292	48	592	..	554	7,486†	71,786
1960–61	18,416	1,296	201	..	21,457	51,370†	701,639

A small quantity of Lavender Water (907 gallons) valued at Rs. 40,845 was imported into India in 1957; the quantities imported in 1958 and 1960–61 were negligible; no lavender water was imported in 1959.

* Quantity in gallon.

† Quantity in lb.

n.a. not available.

is above 30,000 lb. The entire quantity is imported. Table 2 gives the quantity and value of imports in recent years.

L. stoechas Linn. FRENCH LAVENDER

D.E.P., IV. 595; Bailey, 1947. II. 1829; Chaytor, *J. Linn. Soc., Bot.*, 1937–38, **51,** 163.

HINDI—*Dharu*; GUJ.—*Lavendara-na-phula.*

BOMBAY—*Ustukhudusa, alphajan.*

A fragrant herb, 0.6–0.9 m. high, native of the Mediterranean region, grown in some gardens in western India. Leaves sessile, oblong-linear; flowers small, dark purple, in dense short-peduncled spikes.

Dried flowering tops, on steam-distillation, yield 0.75% of a volatile oil possessing a strong camphoraceous, somewhat harsh, odour suggestive of spike lavender and rosemary oils. The characteristics of the French oil are as follows: sp. gr.$^{15°}$, 0.945–0.962; $[\alpha]$, +35.5° to +47.0°; acid val., 0.93–5.16; ester val., 13.1–17.74 (after acetylation, 47.14): sol. in 5 vol. and more of 60% alcohol. The oil contains 80% ketones (*d*-camphor and *d*-fenchone); cineole and fenchyl alcohol and probably terpineol are present. Oils of Portuguese origin consist chiefly of esters and alcohols (Guenther, III, 515–18; *Chem. Abstr.*, 1949, **43,** 9381).

The dried plant and flowers are medicinal; they are reported to be imported into Bombay from the Persian Gulf. The flowers are used in perfumes, medicated pillows or cushions, herb sachets and fumigating powders. Oil of *L. stoechas* is prescribed in colic and chest affections and for relieving biliousness and nervous headaches. It is used also as moth repellent. Fomentation with flowers gives relief in rheumatic and neuralgic pains (Hocking, 124; Steinmetz, II, 268; Nadkarni, I, 730; Paulet, *Perfum. essent. Oil Rec.*, 1956, **47,** 232).

Lavender — *see* **Lavandula**

Lawson Cypress — *see* **Chamaecyparis**

LAWSONIA Linn. (*Lythraceae*)

A monotypic genus, represented by *L. inermis*, native of North Africa and south-west Asia, widely cultivated as an ornamental and dye plant.

L. inermis Linn. syn. *L. alba* Lam. HENNA, EGYPTIAN PRIVET

D.E.P., IV, 597; VI (1), 137; C.P., 706, 821; Fl. Br. Ind., II, 573.

SANS.—*Mendika, raktgarbha, ragangi*; ARAB.—*Henna, al khanna;* HINDI—*Mehndi;* BENG.—*Mehedi, mendi*; MAR.—*Mendhi*; GUJ.—*Medi, mendi*; TEL.—*Goranti*; TAM.—*Marithondi, maruthani*; KAN.—*Mayilanchi, gorante*; MAL.—*Mailanchi, pontlasi*; ORIYA—*Benjati.*

KASHMIR—*Mohuz*; PUNJAB—*Mehndi*; MUNDARI—*Mindi, bind.*

A glabrous, much branched shrub or small tree with greyish brown bark. Leaves opposite, sub-sessile, elliptic or broadly lanceolate, entire, acute or obtuse, often mucronulate; flowers numerous, small, white or rose-coloured, fragrant, in large terminal pyramidal panicled cymes; capsule globose, about the size of a pea, with numerous, pyramidal, smooth seeds.

L. inermis is cultivated in many tropical and warm temperate regions as a hedge plant. Large scale cultivation for the sake of the leaves which yield the dye, is confined to India, Egypt and Sudan and to some extent, Persia, Madagascar, Pakistan and Australia. It is grown as a hedge plant throughout India: as a commercial dye crop, it is cultivated mainly in Punjab and Gujarat, and to a small extent in Madhya Pradesh and Rajasthan. The more important centres of production are: Faridabad in Gurgaon district (Punjab) and Bardoli and Madhi in Surat district (Gujarat) which together account for 87% of the total production of henna leaves (Roberts & Kartar Singh, 495; *Agric. Marketing India*, No. 86, *Brochure Marketing Henna*, 1955, 1–2).

Cultivation—Henna plant grows on any type of soil, from light loam to clay loam, but does best on heavy soils which are retentive of moisture. It tolerates a little alkalinity in the soil. Propagation is done by seeds and cuttings. Seeds are sown in nursery beds, kept flooded with water for some days before sowing. They are first soaked in water for 20–25 days with frequent changes of water for sprouting and then sown in March–April. Three to five seers of seeds are required to raise enough seedlings to cover one acre. When seedlings are 1½–2 ft. high, they are transplanted in the field (in July–August) after cutting out the roots and shoots. They may be planted singly or 2–3 together in holes at a spacing of 12 inches in irrigated lands and 6 inches in unirrigated lands. Daily irrigation is necessary in the initial stages. The field is occasionally hoed and weeded. Once established, the plants continue to flourish and yield successive crops of leaves for several years; some plantations are reported to be in continuous yield for 100 years. For hedging, propagation by cuttings is convenient (Roberts & Kartar Singh, 495–96; *Brochure Marketing Henna*, 1955, 2).

L. inermis is subject to black rot disease, caused by *Corticium koleroga* (Cooke) V. Hoehn. A bacterial leaf spot, caused by *Xanthomonas lawsoniae* Patel, Bhatt & Kulkarni, has been reported from Baroda (*Indian J. agric. Sci.*, 1950, **20,** 107 ; Patel *et al.*, *Curr. Sci.*, 1951, **20,** 326).

The crop is harvested twice a year (April–May and October–November) from the second year onwards. The plant is cut close to the ground, dried in shade and leaves separated by beating (*Brochure Marketing Henna*, 1955, 3).

The yield of dry leaves is low during the first 2–3 years and varies from 2 to 10 md. per acre ; it increases later to 13–20 md. The yield from irrigated fields is reported to be 25 md. per acre per annum. The harvest during October–November (summer crop) accounts for 75–85% of the total annual yield (Roberts & Kartar Singh, 496 ; *Brochure Marketing Henna*, 1955, 2).

Uses—Henna has long been used in India and Middle East countries for colouring palms of hands, soles of feet and finger nails. It is used also for dyeing hair, beard and eye brows, for personal adornment. Tails and manes of horses are sometimes dyed with henna, which is also used for colouring leathers and skins.

For use as colouring material, henna powder is pasted with water and applied to the part to be dyed. For dyeing hair it is applied as a pack ; it acts as a substantive dye for keratin and imparts an orange-red colour. It is harmless and causes no irritation of skin. Mixture of henna with indigo, logwood or any other natural plant colouring matter gives Compound Henna used by hair dressers as vegetable pack. A mixture of 1 part of henna and 2 parts of indigo, Henna-Reng as it is called, imparts a brown tint, while henna-reng containing 1 part of henna and 3 parts of indigo gives a dark brown colour. Henna Rasticks contain certain metallic salts and phenolic compounds like aminophenol and pyrogallol ; they are compounded to produce any desired shade from blond to black. Compounded hennas may contain copper salts, *p*-phenylenediamine and burnt sienna (Hill, 129 ; *Brochure Marketing Henna*, 1955, 7–8 ; Milne *et al.*, 71 ; Kirk & Othmer, XIV, 170, 176 ; Thorpe, VI, 171 ; Poucher, III, 83).

Henna was once extensively used for dyeing silk and wool. A wide range of colours may be imparted by treating henna-dyed fabrics in acid baths containing potassium dichromate, ferrous sulphate, stannous chloride or alum. Cotton hanks previously treated with acidified ferrous sulphate solution are coloured cement-grey when dyed with henna extract. The use of henna as a textile dye has declined since the advent of synthetic dyestuffs (Rehsi & Daruvala, *J. sci. industr. Res.*, 1957, **16A,** 428).

Henna leaves are used as a prophylactic against skin diseases. They have astringent properties. They are used externally in the form of a paste or decoction against boils, burns, bruises and skin inflammations. A decoction is used as gargle for relaxed sore throat. Alcoholic extracts of henna leaves show mild antibacterial activity against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli* (Kirt. & Basu, II, 1078–79 ; Burkill, II, 1324 ; George *et al.*, *J. sci. industr. Res.*, 1947, **6B,** 42).

Analysis of air-dried leaf powder (from Punjab) gave the following average values: moisture, 8.97 ; ash, 14.85 ; and tannin, 10.21%. The tannin content appears to be very variable ; a sample from Jammu & Kashmir contained 4.9% tannin. Henna contains 25–33% water-soluble matter ; aqueous solutions are orange in colour and show a green fluorescence. The principal colouring matter is lawsone, 2-hydroxy-1 :4-naphthaquinone ($C_{10}H_6O_3$, m.p. 190° decomp.) which is present in dried leaves in a concentration of 1.0–1.4%. Henna extracts are useful for dyeing in acid baths ; alkalis intensify the colour but destroy the dyeing properties. Processes for the extraction of lawsone from henna have been patented. Lawsone has also been synthesised [Siraj-ud-Din, *Punjab Fr. J.*, 1957, **21**(77), 17 ; Singh *et al.*, *Indian For.*, 1958, **84,** 571 ; B.P.C., 1934, 588 ; *Chem. Abstr.*, 1938, **32,** 6399 ; Thorpe, VI, 204 ; Lal & Dutt, *J. Indian chem. Soc.*, 1933, **10,** 577 ; Poucher, I, 204 ; Jain & Seshadri, *Proc. Indian Acad. Sci.*, 1952, **35A,** 233].

Besides lawsone, other constituents present in henna are: gallic acid, glucose, mannitol, fat, resin (2%), mucilage and traces of an alkaloid (*Chem. Abstr.*, 1938, **32,** 6399 ; Youngken, 585 ; Quisumbing, 643).

The flowers of henna plant have a strong aroma and yield, on steam-distillation, 0.01–0.02% of an essential oil (sp. gr.$^{15°}$, 0.9423 ; $n_D^{20°}$, 1.520), with brown or dark brown colour and a strong fragrance suggestive of tea rose and mignonette (*Reseda odorata* Linn.). Henna or *mehndi* oil has been used in perfumery since ancient times and is reported to be extracted on a commercial scale in Lucknow and Banaras. It consists mainly (90%) of α- and β-ionones (ratio 1 :4) : a nitrogenous compound and a resin are present. Extraction of flowers with benzene yields

LAWSONIA INERMIS — FLOWERING & FRUITING BRANCHES

1.65% of a semi-solid concrete (acid val., 16.8; ester val., 62.0) with an agreeable odour, somewhat phenolic and very tenacious [Krishna & Badhwar, *J. sci. industr. Res.*, 1950, **9A**(4), suppl., 239; Burkill, II, 1325; Antia & Kaushal, *Curr. Sci.*, 1950, **19,** 284; Baslas, *J. Indian chem. Soc.*, 1954, **31,** 705; Naves & Mazuyer, 272; *Chem. Abstr.*, 1944, **38,** 3085].

Analysis of henna seeds gave the following values: moisture, 10.6; protein, 5.0; fatty oil, 10–11; carbohydrates, 33.62; fibre, 33.55; and ash, 4.75%. Extraction of the seeds with petroleum ether yields a non-drying viscous oil, with the following characteristics: sp. gr.$^{30°}$, 0.9545; $n^{20°}$, 1.4895; sap. val., 149.0; iod. val., 59.98; acid val., 18.2; acet. val., 9.2; and unsapon. matter, 10.5%. The fatty acid composition of the oil is as follows: behenic, 1.69; arachidic, 9.6; stearic, 15.78; palmitic, 9.07; oleic, 34.66; and linoleic, 29.31%. The unsapon. matter contains waxes and colouring matter. The oil is reported to be used in Uganda for anointing the body. The root contains a red colouring matter (Wehmer, II, 816; Agrawal et al., *Indian Oil & Soap J.*, 1959–60, **25,** 145; Burkill, II, 1325; Perkin & Everest, 632).

The wood is grey, hard and close-grained. It is used for tool handles and tent pegs. Twigs are used in Indonesia for cleansing teeth (Burkill, II, 1325).

Production of Henna & Trade—Details relating to the acreage under henna cultivation in different Indian States are not available. The annual production of dried leaves is estimated at 65,000–70,000 md. The major producer is Punjab (31,000–32,000 md.) followed by Gujarat (26,000–29,000 md.), Madhya Pradesh (5,000–5,500 md.) and Rajasthan (3,000–3,500 md.) (*Brochure Marketing Henna*, 1955, 1).

About 15% of the total production is consumed within the country in the form of powder; the rest is exported in the form of dried leaves or powder. The principal importing countries are France, Syria, Algeria, Tunis, Bahrein and Jordan. France is the chief importer of henna leaves followed by U.K.; henna powder is imported by Middle East countries, northern Africa and U.S.A. Statistics of henna exports are available from 1957 onwards (Table 1) though figures for leaves and powder are not separately available. For export, leaves are pressed into bales each weighing 3 cwt. and covered with hessian cloth. Henna powder is packed in double gunny bags of the capacity of 160 lb. net of powder (*Brochure Marketing Henna*, 1955, 5, 7–9, 11–12).

Three grades or qualities of henna are recognized in the trade and designated Delhi, Gujarat (also known as Bombay) and Malva. Henna of Delhi quality is marketed in the form of powder and the principal marketing centre is Faridabad. Primary producers sell leaves to merchants, who, after cleaning, dispose of the produce to factories in Faridabad for conversion into powder. Gujarat henna is available in the form of leaves; the produce is collected from villages by itinerant merchants who send it to Bombay for export; one processing factory is located in Madhi (Surat dist.). Malva henna is the produce of Rajasthan, the main trading centre being Bhawani mandi near Kotah; it is marketed in the form of powder.

TABLE 1—EXPORTS OF HENNA LEAVES AND POWDER

Importing countries	1957		1958		1959		1960	
	Qty (cwt.)	Val. (Rs.)	Qty (cwt.)	Val. (Rs.)	Qty (cwt.)	Val. (Rs.)	Qty (cwt.)	Val. (Rs.)
France	10,815	293,665	16,838	617,203	30,914	1,154,086	12,864	505,785
Syria	1,413	46,991	1,010	35,600	3,720	174,327	3,488	154,953
Jordan	1,905	56,308	361	9,294	400	12,234	60	1,836
Bahrein	561	14,150	931	33,884	500	21,594	81	3,621
Algeria	..	..	1,096	53,032	9,913	372,687	25,542	886,172
Tunis	1,666	116,448	2,239	125,504	780	47,047	2,625	117,194
Tangier	639	22,616	300	10,239	100	4,267	..	..
U.K.	563	14,314	247	8,034	384	11,773	181	5,256
U.S.A.	995	28,301	800	28,158	188	9,488	560	25,312
Others	419	14,998	346	15,330	3,818	182,971	15,341	850,124
Total	18,976	607,791	24,168	936,278	50,717	1,990,474	60,742	2,550,253

TABLE 2—WHOLESALE PRICES OF DIFFERENT BRANDS OF HENNA POWDER IN DELHI (FEBRUARY 1959)*

Brand	Price per md. (Rs.)
Gopal Chhap	47.00
B.R.	45.00
Phool	43.00
Sunhari Phool	42.00
K.K.	40.00 42.00
Khujran	38.00
Tota	36.00
Savanki Bahar	35.00
Om	34.00–35.50
Hans	34.00
Sabaz Pari	31.00
Rat Ki Rani	31.00
Swastik	30.00 31.50
Lotus	28.00
Sunder Phool	27.00
Sher	27.00
Suraj	18.00–21.00

* Information from Messrs. *Bansidhar Ramgopal,* Delhi.

Delhi henna is superior to others in dye content; Malva henna and Gujarat henna follow in order (*Brochure Marketing Henna,* 1955, 2–6, 8; Information from Messrs. *Bansidhar Ramgopal,* Delhi).

The quality of henna powder is determined by its colour, purity and fineness. Manufacturers market their produce under different trade marks. More than 15 brands are available in Delhi market (Table 2); the best among them contains *c.* 95% henna. Henna powder is adulterated with sand, stems and fruits of henna plant and husks of paddy, *arhar* and *moong,* etc. Leaves are sometimes adulterated with the leaves and twigs of other shrubs (*Brochure Marketing Henna,* 1955, 3, 5–7; Roberts & Kartar Singh, 496).

The chief competitors to Indian henna in the export market are Egyptian and Sudanese products. Indian henna powder is reported to contain an unusually high percentage of impurities: the qualities of Sudanese henna leaves are superior and are reported to be available at prices lower than that of the Indian product (*Brochure Marketing Henna,* 1955, 11).

Prices—The wholesale prices of henna leaves quoted in Delhi range from Rs. 38.00 to Rs. 45.00 per md. (February 1959). Wholesale prices of powder are very variable and range from Rs. 47.00 per md. for 95% pure henna to Rs. 18.00 per md. for inferior grades (Table 2). Henna prices are greatly influenced by the prices prevailing in importing countries (Information from Messrs. *Bansidhar Ramgopal,* Delhi).

LEAD ORES

Lead is a soft, heavy and noncorrosive metal, known since ancient times. It is an important industrial metal, though it is present only to a small extent (<0.05%) in the earth's crust. It occurs mainly in the form of sulphide, galena; cerussite and anglesite formed by the alteration of the primary sulphide ore are also of some importance. Other lead minerals are of little commercial significance.

The majority of lead deposits occur in sedimentary rocks in the form of lodes or veins. They may occur as replacements and disseminations in limestone and dolomite and, in a few cases, as residual deposits resulting from the solution of carbonate rocks.

Galena (PbS; Pb, 86.6%; sp. gr., 7.4–7.6; H., 2.5–2.75) is the most important lead ore. It occurs as grey cubic crystals or in massive or granular form. It is usually found in intimate association with sphalerite (ZnS) and often contains silver. If the content of silver exceeds 1%, the mineral is called Argentiferous galena. Other metals which may be present in lead deposits are copper, gold and vanadium.

Galena occurs in lodes and veins, usually formed by complete or partial replacement of a pre-existing rock by ore-bearing solutions; it sometimes occurs also as disseminations in country rock. The gangue minerals in galena veins are quartz, calcite, dolomite, siderite, fluorite or barite.

Cerussite ($PbCO_3$; Pb, 77.5%; sp. gr., 6.46–6.57; H., 3.0–3.5) is a white or greyish white mineral usually found in massive form or as prismatic crystals. It is a mineral of secondary origin derived from galena which is first oxidized to lead sulphate (anglesite) and then decomposed by carbonated waters into carbonate. The mineral occurs in association with galena and anglesite.

Anglesite ($PbSO_4$; Pb, 68.3%; sp. gr., 6.30–6.39; H., 2.75–3.0) is a white, yellow, grey or green coloured prismatic or orthorhombic crystalline mineral, found in association with galena in the upper strata of lead veins; it is rarer than cerussite as it is readily transformed into carbonate.

Pyromorphite ($3Pb_3P_2O_8.PbCl_2$; sp. gr., 6.5–7.1; H., 3.5–4.0) is a green, yellow or brown coloured prismatic mineral showing a resinous lustre. It is

occasionally found in small quantities along with other secondary lead minerals in the oxidized zones of lead veins.

Jamesonite ($2PbS.Sb_2S_3$; Pb, 50.8% ; Sb, 29.5% ; sp. gr., 5.5–6.0 ; H., 2.0–3.0) is a dark grey coloured mineral with acicular or fibrous habit. It is occasionally found in veins associated with antimony trisulphide (stibnite) or copper antimony-sulphide (tetrahedrite).

Zinkenite ($PbS.Sb_2S_3$; Pb, 35.9% ; Sb, 41.8% ; sp. gr., 5.1–5.35 ; H., 3.0–3.5) is a steel-grey coloured opaque mineral, sometimes found associated with jamesonite.

Large deposits of galena, associated with cerussite and anglesite, occur in the United States of America, Australia, Mexico, Canada, U.S.S.R. and a few other countries. Table 1 gives the world production of lead ores in recent years. Production in India is comparatively insignificant.

TABLE 1—WORLD PRODUCTION OF LEAD ORES (Pb content)*
(Qty in thousand metric tons)

	1955	1956	1957	1958†
United States	306.6	320.1	306.8	242.6
Australia	300.7	304.3	338.6	332.3
Mexico	210.8	199.6	214.9	201.9
Canada	183.9	171.3	164.6	168.5
Peru	118.8	129.1	137.2	121.4
Yugoslavia	90.1	87.3	90.1	89.8
Morocco	89.3	88.6	92.8	93.8
South West Africa	79.0	78.1	83.1	76.0
Germany	67.4	65.5	71.1	60.9
Spain	63.6	59.5	65.2	70.1
Bulgaria	51.7	61.0	69.0	78.0
Italy	48.2	49.8	53.8	58.1
Burma	28.5	28.9	27.4	35.4
Japan	26.2	29.5	36.1	36.7
Iran	18.2	31.6	30.4	..
India	2.3	2.9	3.6	3.9‡
Others**	244.7	332.9	265.3	300.6
Total¶	1,930.0	1,940.0	2,050.0	1,970.0

* *Statistical Yearbook*, United Nations, New York, 1959, 138.
† Provisional.
‡ Final estimates, 4.5 thousand metric tons.
** Including Poland, Sweden, Tunisia, Bolivia, Argentina, Northern Rhodesia, Rumania, Algeria, etc.
¶ Excluding U.S.S.R.

OCCURRENCE AND DISTRIBUTION

Lead ore deposits occur in Andhra Pradesh, Assam, Bihar, Kashmir, Madhya Pradesh, Rajasthan and a few other States. Of these, the deposits of Zawar (Rajasthan) are worked at present.

Andhra Pradesh—In Cuddapah district, galena occurs in quartz veins at Jangamrajupali (14°46′: 78°53′), Nagasanipalli (14°42′: 78°49′), Kotlur (14°36′: 78°45′) and Chinuaorampad (14°31′: 79°14′). Lead deposits have been found in Guntur district near Karampudi (16°26′: 79°33′), and in Agnigundala area. In Kurnool district, galena associated with barytes occurs in quartz veins at Basavapuram (15°24′: 78°38′) and Koilkuntla (15°13′: 78°19′). The ore in all the deposits is of poor quality and the quantity available is also limited (Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 157 ; Dewan, 57).

Assam—Argentiferous galena occurs in Bor Khamti in Abor hills, N.E.F.A. ; detailed information is lacking. Galena is also found in granitic boulders south of Umwang (25°41′: 92°12′) in Khasi and Jaintia hills [Dutt, *Indian Min. J.*, 1957, **5**(10), 32 ; Bradshaw, *Rec. geol. Surv. India*, 1934, **68**(1), 39].

Bihar—Galena associated with silver occurs in numerous small patches in various parts of Hazaribagh, Manbhum, Bhagalpur, Ranchi and Singhbhum districts. The deposits may be grouped under two belts: one running across north Singhbhum and south Manbhum in the southern part of the State, and the other extending from Palamau district through Hazaribagh and Monghyr districts into south Bhagalpur district and Santal Parganas. Most of the occurrences seem to have no commercial importance. A few, however, merit detailed prospecting [Jacob & Mahadevan, *Indian Min. J.*, 1957, **5**(10), 53].

In Singhbhum district, galena is found associated with auriferous quartz veins of Pahardiah (22°30′: 85°16′) and Sausal (22°37′: 85°17′). Samples from a vein near Pahardiah contained 79.3% lead with 34 oz. 2 dwt. 17 gr. silver and 11 oz. 2 dwt. 3 gr. gold per ton of lead. Small pockets of galena containing 78.46% lead are found associated with copper pyrite and iron pyrite in a hill north-east of Amda (22°43′: 85°44′).

In Manbhum district, galena occurs as superficial deposits in small lenticular masses at several localities within a radius of 6 miles from Dhadka (22°48′: 86°34′). Associated with galena, are cerussite, iron pyrite, copper pyrite and siderite. From a similar deposit at Beldi (23°3′: 86°18′), 267 tons of ore, yielding about 90 tons of lead and small quantities of gold and silver, were extracted in 1904 and 1905.

In Bhagalpur district, argentiferous galena occurs in several localities notably at Dudhijharna (24°53′: 86°45′), Karda (24°46′:86°43′), Kajuria (24°42′: 86°44′), Phaga (24°46′:86°56′) and Kharikhar (24°50′:86°45′). A surface sample from Dudhijharna contained 71% lead with 42 oz. 3 dwt. silver per ton of lead; samples from Phaga deposit analysed to about 72% lead. Pyromorphite is reported to occur at Chandun (24°37′:86°40′) [Dunn, *Mem. geol. Surv. India*, 1941, **78**, 162: Coulson, *Rec. geol. Surv. India*, 1929, **62**(2), 291].

In Hazaribagh district, galena occurs in the Patru stream near Gulgo (24°24′:86°25′30″) and at Parasiya (24°10′:85°48′), Hisatu (24°0′:85°1′), Nyatand (24°30′:85°43′) and Baragunda (24°5′:86°7′). The specimens from Hisatu deposit contain 47.02% lead and 4.7% antimony. Fragments of cerussite are found near Baramasia (24°20′:86°16′) and Nawadih (24°29′:86°22′) (Dunn, *Mem. geol. Surv. India*, 1941, **78**, 161).

In Ranchi district, galena has been recorded from Sili (23°21′:85°50′) and Silwai (23°23′:85°27′).

In Santal Parganas, galena occurs in Panch Pahar (24°38′:87°10′) and Bhairukhi (24°36′:86°36′) (Dunn, *Mem. geol. Surv. India*, 1941, **78**, 162).

Gujarat—In Panch Mahals, irregular thin veins and stringers of quartz-argentiferous galena occur c. half a mile north-east of Khandia (22°19′:73°35′) in the former Bhamria state. There are two parallel mineralized zones about a furlong apart and extending for about half a mile; the width of one of the zones varies from 2 to 4 ft. Traces of galena in association with wolfram, chalcopyrite and iron pyrite occur near Jher (22°35′:73°42′) and Palla (23°34′: 73°42′) in Baria. The deposits are not of any economic importance.

In Chota Udaipur, traces of galena, analysing to 78.2% lead and 6.21–15.03 oz. silver per ton, occur near Khatas (22°30′:73°50′) (Roy, 1951, 138).

In Kathiawar, galena associated with chalcopyrite, bornite, tetrahedrite and malachite occurs in a quartz vein at Banej Nes (21°3′:70°53′) in Gir Forest. The vein ranges in width from a few inches up to 1 ft. and extends for a considerable distance. A specimen of lead ore from this area analysed to 81.68% lead and 9.2 oz. of silver per ton. Further exploration of the area has been recommended (Roy, 1953, 159).

Himachal Pradesh—Galena occurs in Sirmur district at Aiyur (30°46′:77°46′) in a well defined lode c. 2 ft. in width. Small occurrences of galena are also found in Amba (30°38′30″:77°27′30″), Kakag (30°38′ : 76°26′) and Kando (30°38′30″ : 77°27′) (Dewan, 57).

Kashmir—In Baramula district, galena occurs in nodular masses, stringers and patches in a locality about 3 miles south-east of Buniyar (34°6′:74°12′) and near Limbar, 2½ miles north-west of Buniyar. The mineralization is confined to quartz veins and stringers in the Buniyar area. Analysis of galena from the former locality gave 65.5% lead and 30 oz. 18 dwt. of silver per short ton.

In Udhampur district, ancient lead mines are situated at Nigote. Fissure veins and disseminations of galena occur over a length of 2 miles in the Great Limestone formation at a depth of 4–20 ft. below the surface. Due to the erratic nature of mineralization, no estimate of total reserves is available [Mehta, *Indian Min. J.*, 1957, **5**(10), 61].

Madhya Pradesh—In Bilaspur district, galena occurs sparsely distributed in a bed of limestone in Mahanadi river at Padampur (21°45′:83°37′).

In Drug district, galena associated with fluorite occurs in a quartz vein at Chandi Dongri (20°4′: 80°37′). The proportion of galena in the vein is reported to be small. Traces of galena also occur near Muhripar (21°21′:80°52′), Thelkadand (20°37′: 80°45′) and Karamtara (20°41′:80°48′).

In Jabalpur district, galena occurs in association with copper pyrite and some other minerals at Sleemanabad (23°38′:80°19′). In Hoshangabad district, small quantities of argentiferous galena occur disseminated in limestone at Joga Khurd (22°24′: 76°51′).

In Shivpuri district, galena occurs as small veinlets, patches and streaks at Andar (25°32′:78°6′), about 7 miles north-west of Karera on the Jhansi-Shivpuri Road. The deposit was worked for some time but abandoned later.

In Gird (Gwalior) district, small amounts of galena occur at Badhano (26°6′:78°25′), Karaia (25°54′: 78°4′) and Raghunathpur (26°4′:78°20′). In Dewas district, galena occurs sparsely distributed near Nimawar and Joga (22°26′:76°48′). These occurrences are of no economic importance (Roy Chowdhury, *Bull. geol. Surv. India, Ser. A*, No. 10, 1955, 43).

Mysore—In Hospet taluk (Bellary dist.), lead ore has been found at Metri (15°19′:76°37′), about 25 miles north-west of Bellary town, in commercially exploitable quantities. Ore samples assay 82.53% lead, 12.77% sulphur and 2.71 oz./ton of silver. Estimates of reserves of ore in the deposits are not available.

Galena has also been found in the quartz veins west of Konagavalli in Shimoga district [Coggin Brown & Dey, 156; Rao, *Rec. Mysore geol. Dep.*, 1954, **49**(1), 46].

Orissa—In Sambalpur district, argentiferous galena occurs in a vein of quartz, 16–19 in. wide, in the bed of Mahanadi river at Jhuman (21°32′:83°54′).

In Sundergarh district, veins and stringers of galena occur in association with copper pyrite, malachite and pyromorphite near Sargipali (22°3′:83°55′). Traces of galena also occur in former Jashpur state near Bundurchua (22°41′:83°54′), Singibahal (22°33′:84°0′) and Phardbahar (22°25′:83°55′). The deposits are of no economic importance.

Punjab—In Kangra district, quartz veins containing galena, pyrite and arsenopyrite traverse the slates at Jhari (32°0′:77°18′). Galena occurs in massive form associated with silver and gold at Saugthan, 5 miles from Jhari, and as argentiferous lodes near Manikarn (32°2′:77°25′). Near the latter area, the lodes at Khanor Khud, Uchich and Chong appear quite promising.

In Spiti area, galena occurs as small isolated cubes in a small quartz vein between Po (32°3′:78°23′) and Dandkhar (32°5′:78°16′).

In Simla district, old lead mines exist at Sar (30°53′:77°15′), near Subathu and at Basantpur (31°12′ 30″:77°14′). Galena bearing lodes sometimes carry copper minerals and traces of gold and silver (Dewan, 57).

Rajasthan—Lead ore occurs at several places in the State. The most important deposit occurs at Zawar (24°21′:73°45′) in Udaipur district and is about 15 miles due south of Udaipur city. The ore is being mined and concentrated at the mine site at Zawar; the concentrate is sent to Tundoo in Bihar for extraction of lead metal.

The Zawar deposit occurs in a group of 10–12 hills with many ancient mine workings. Extensive and deep workings occur in Mochia Mangra, Baror Mangra and Zawar Mala hills. At present only the Mochia Mangra hill is being worked; attempts are being made to start operations at Zawar Mala. The ore consists mainly of argentiferous galena and sphalerite, associated with pyrite, aresenopyrite, chalcopyrite, quartz and crystalline dolomite. Mineralization appears to continue down to a depth of 1,000 ft. or more. The average grade of the run-of-mine ore contains 8.5% metal content of which lead is 3–4% and zinc, 4.5–5.5%.

The proved and estimated ore reserves at Mochia Mangra are 700,000 tons of A grade ore (Pb, 5.25% and Zn, 7.25%) and 2 million tons of B grade ore (Pb, 1.9% and Zn, 3.8%). Probable reserves of lower grade ore, containing 3% or more of lead and zinc, have been estimated at 8 million tons (*Mineral Production in India*, Indian Bureau of Mines, 1957, 101; Roy, *Mem. geol. Surv. India*, 1959, **86**, 311).

In addition to Zawar deposits, galena has been recently located at Rikhabdeo (24°15′:73°40′) and Debari (24°37′:73°36′) in Udaipur district. Further prospecting is in progress (Sethi, 34).

In Dungarpur district, evidence of lead ore veins associated with quartz has been found at Ghughra and Mando (73°54′:23°46′). In Banswara district, lead ores occur at Wardipura and Kadbalia. In the latter deposit galena occurs as an ore-shoot in granite-gneiss and was worked in 1944.

In Sawai Madhopur district (Jaipur division), galena and cerussite occur at Chauth-ka-Barwara (26°3′:76°12′); cerussite forms the bulk near the surface, galena is found *c.* 20 ft. below the surface and increases with depth. Further exploration to prove the extent of lode has been recommended. In Alwar district, galena occurs in small quantities at Gudha (27°21′:76°20′); lead ore has also been recorded at Judawas (27°21′:76°22′) (Sethi, 35; Roy, *Mem. geol. Surv. India*, 1959, **86**, 204, 203).

In Ajmer-Merwara abandoned lead workings are found at the base of Taragarh hill in Ajmer (26°27′:74°40′). The ore occurs in parallel veins and consists of anglesite, cerussite and galena. The mine was operated from 1818 to 1846 and produced annually 340–400 tons of lead. Galena also occurs as disseminations near Satana (25°58′:74°40′), Sawar (25°45′:75°16′) and Ganeshpura (26°1′:74°42′) (Roy, *Mem. geol. Surv. India*, 1959, **86**, 202).

Uttar Pradesh—In Dehra Dun district, several old mines are situated in the Tons river valley *c.* 25 miles from Kalsi (30°32′:77°54′). Lead is also reported to occur at Kuma (30°41′:78°6′), Kharsi (30°45′:78°2′), Konain (30°47′:77°57′) and Mudhaul (30°56′:77°51′).

In Almora district, sizable lead ore deposits occur in Patti Kharahi area. Explorations have been recently carried out at Chhanapani, 3/4 mile north-west of Chaugaon Chhinna (29°47′:79°46′), and Shishkhani (29°48′:79°45′) in the area. In the former locality, the lead-bearing zone is approximately 200 yd. × 200 yd. and the ore contains, on an average, 6% lead. The mineralized zone, in Shishkhani area is 500 yd. × 150 yd. with an average lead content of 1%. The area appears promising (*J. sci. industr. Res.*,

1955, **14A,** 551; Narayana Rao, *Mineral Wealth of Uttar Pradesh*, 1956, 5).

In Tehri-Garhwal district, galena occurs in a quartz vein at Pindki (30°55′:78°25′); further prospecting is necessary to prove its persistence in depth [Dutt, *Rec. geol. Surv. India*, 1950, **83**(1), 135].

Mining and Beneficiation

The Zawar deposits were worked continuously for over 400 years, from the end of the fourteenth century to 1812–13. The ore was extracted from detached pockets or hollows at the surface. Attempts to open up old workings were made during World War II, first by *Mewar Mineral Co.*, Udaipur, during 1940–42 and later by the Geological Survey of India between 1942 and 1945. The latter undertook extensive exploration of the Mochia Mangra hill but gave it up at the close of the war. The area was subsequently leased out to *Metal Corporation of India*. At present the ore is mined from the Mochia Mangra deposit and concentrated at the mine site.

The deposit is worked by driving tunnels below the sites of ancient workings; out of the five adit sites selected, only one adit has exposed workable deposits. The mine is worked by shrinkage stope and sub-level stoping. The ore was being concentrated by hand picking up to 1950; ore dressing mill has since been set up and the ore is now beneficiated by mechanical means.

Beneficiation—The economic minerals present in the ore are galena containing a small quantity of silver, and sphalerite associated with a little cadmium; the gangue minerals are dolomite, quartz and pyrite. The average grade ore worked in recent years assays 3–4% lead, 4.5–5.5% zinc and 4–6 oz./ton silver. The run-of-mine ore is trammed to the crushing mill shed and discharged on a 8 in. grizzly. The over-size is reduced to bits by sledge hammering and crushed, in three stages, to ½ in. size by passing through a jaw crusher and two reduction crushers. The stray iron particles are removed from the crushed ore with the help of a circular magnet, the ore is then passed *via* a conveyor belt to ball mills. The crushed ore is ground in closed circuits with classifiers and concentrated by Denver flotation cells using zinc sulphate and sodium cyanide as depressants for sphalerite, potassium ethyl xanthate as collector and cresylic acid as frother. Galena floats up and is collected; the tailings are sent to other cells for concentrating sphalerite. Zince ore is activated with copper sulphate and floated. The lead concentrates are pumped to a thickener and the discharge filtered in a disc filter. The filter cake is packed and sent to Tundoo (Bihar) for smelting. The average composition of lead concentrate is as follows: lead, 72; zinc, 7.5; sulphur, 15.7; copper, 0.02; antimony, 0.04%; and silver, 30 oz./ton [Mukherjee, *Indian Min. J.*, 1957, **5** (Spec. Issue), 220; Mackertoom, *ibid.*, 1957, **5** (Spec. Issue), 224].

Smelting—For obtaining the metal, the concentrate is mixed with fluxes (iron ore, limestone, sand and slag) in appropriate proportions and sintered in an air blast till the sulphur content is reduced to 2% or less. The sinter, along with coke and fluxing materials, is charged into a blast furnace. The temperature in the shaft increases from about 150° at the top to 1,000–1,200° at the tuyere level. As the charge descends through the shaft the lead oxide in the sinter is reduced to metal and collects at the bottom of the slag containing fluxing ingredients. The molten metal is tapped and cast into blocks of pig lead containing 99.29% lead and small amounts of silver, copper, antimony, nickel, zinc, etc. Pig lead is further refined to obtain pure metal and silver (Wlth India—Industrial Products, pt V, 197).

Properties and Uses

Lead is a soft, heavy metal, highly pliable and malleable but only slightly ductile. It can be readily rolled into thin sheets and extruded into tubes and rods. On account of its high resistance to corrosion, lead is used as inside lining for acid chambers, tanks, sinks, vats, etc. Lead pipes are used for conveying drinking water and industrial gases. Because of its high density lead does not transmit nuclear radiations or become radioactive. In the field of atomic energy it is being increasingly used in nuclear reactors in the form of extended blocks for shielding radiations.

Lead forms alloys with antimony, tin and other metals which make it still more useful in many industries. Antimony and copper harden lead and improve its mechanical properties, whereas tin increases its casting qualities. Lead-antimony alloys with small amounts of tin, arsenic and/or copper are extensively used in the manufacture of storage battery grids, cable sheath metal and bullets; antimonial lead sheets and pipes being acid resistant are widely used in chemical industry. Lead-antimony-tin alloys are used as type metals for printing presses and Babbitt's metal or bearing alloy. Small amounts of barium and strontium added to lead also give

TABLE 2—PRODUCTION AND COMPOSITION OF LEAD ORE AND LEAD AND ZINC CONCENTRATES*

	Lead ore			Lead concentrate			Zinc concentrate‡
	Ore treated	Composition		Production	Composition		Production
	(tons)	Pb (%)	Zn (%)	(tons)	Pb (%)	Zn (%)	(tons)
1951–52	21,266	5.62	8.00	1,334	73.0	6.75	2,840
1952–53	36,170	4.50	6.70	2,078	73.5	6.35	3,716
1953–54	46,754	4.93	6.19	2,836	73.4	6.78	3,977
1954–55	49,065	4.68	6.00	2,986	71.4	6.60	4,437
1955–56	53,440	4.70	5.94	3,097	74.0	5.33	5,107
1956–57	85,415	3.90	5.49	4,143	72.5	6.15	7,660
1957–58	96,643	4.08	4.55	4,877	74.9	4.60	6,789
1958	109,756¶	4.12	4.37	5,341¶	74.4	n.a.	7,391¶
1959	145,000¶	3.66	4.53	6,488¶	75.0	n.a.	9,978¶
1960†	147,000¶	3.32	4.32	6,245¶	72.5	5.7	9,787¶

* Mukherjee, *Indian Min. J.*, 1957, **5** (Spec. Issue), 222; information from Messrs. *Metal Corporation of India*, Calcutta; *Provisional Estimate of Mineral Production in India*, Indian Bureau of Mines, 1959, 21; 1960, 14.
‡ Composition: Zn, 52–57; Pb, 0.5–3.5%. † Provisional. ¶ Metric tons.

TABLE 3—PRODUCTION OF REFINED LEAD

	Qty (tons)
1951	859
1952	1,132
1953	1,694
1954	1,791
1955	2,234
1956	2,497
1957	3,175
1958	3,387†
1959	3,958†
1960	3,730†

†Metric tons.

TABLE 4—IMPORTS OF LEAD ORE AND CONCENTRATES
(Qty in tons and Val. in Rs.)

	Qty	Val.
1945–46 to 1949–50(av.)	324	2,37,148
1950–51	35	77,872
1951–52	265	4,16,011
1952–53	49	1,13,680
1953–54	66	1,46,235
1954–55	119	2,45,947
1955–56	252	4,37,862
1956 (April–Dec.)	467	2,38,023
1957	102	3,33,954
1958	110	1,92,084
1959	130	2,17,828
1960	77	1,43,006

bearing metal. Lead-tin alloys in all proportions are used for soft solders, pewters and toys, and as coatings for sheet steel in the production of terne plates. Copper bearing lead (Cu, 0.06%) is used as flexible coverings for electric power and communication cables. Lead containing up to 1% arsenic is used as shots in cartridges and other ammunitions. Fusible alloys containing lead, tin, bismuth and cadmium are used as fuses for electric circuits, safety plugs, etc. (Wlth India—Industrial Products, pt V, 191; Mantell, 1958, Sec. 8, 3).

A major use for lead is in the manufacture of tetraethyl lead, used as an anti-knock in motor petrol. It is also used in substantial quantities in the manufacture of pigments like white lead, red lead and litharge.

Production and Trade

Table 2 gives the quantity and composition of ore treated at Zawar mine site and the composition of the concentrate. Table 3 gives the production of refined lead in India during 1951–1960.

Imports—Table 4 gives the import of lead ores during 1945-46 to 1960.

Prices—The spot price of virgin lead in Calcutta varied between Rs. 123.98 and Rs. 144.37 per 100 kg. in 1960.

Lead Tree — *see* **Leucaena**

Lebidieropsis — *see* **Cleistanthus**

Ledger Bark — *see* **Cinchona**

LEEA Linn. (*Vitaceae*)

A genus of small trees, shrubs or herbs distributed in the tropical and sub-tropical regions of the Old World. About 20 species are found in India.

L. aequata Linn. syn. *L. hirta* Roxb. ex Hornem.

D.E.P., IV, 617 ; Fl. Br. Ind., I, 668 ; Kirt. & Basu, Pl. 258.

HINDI & BENG.—*Kakajangha* ; TEL.—*Surapadi, velanasandi.*

KHASI—*Dieng-soh-phyrnu-iong.*

A shrub, 1.2–3.0 m. in height, found in the north-eastern part of India, Orissa, northern Circars and Andaman Islands. Leaves usually 2-pinnate: leaflets ovate-lanceolate ; flowers in short compact cymes, whitish or greenish ; berries depressed-globose, black when ripe.

The plant possesses anti-tubercular properties. On steam distillation it yields 0.15% of an essential oil which inhibits the growth of *Mycobacterium tuberculosis* in a concentration of 10 μg./cc. The oil also inhibits the growth of *Micrococcus pyogenes* var. *aureus* and *Pasteurella pestis* in concentrations of 100 μg./cc. and 50 μg./cc. respectively. Root tubers and stems are mucilaginous and astringent. Leaves and twigs have antiseptic properties and are used for poulticing wounds (Chopra, 1958, 601 ; Gupta & Chopra, *Indian J. med. Res.*, 1953, **41**, 427 ; Nadkarni, I, 732 ; Burkill, II, 1326).

L. crispa Linn.

D.E.P., IV, 616 ; Fl. Br. Ind., I, 665 in part ; Kirt. & Basu, Pl. 255.

BENG.—*Banchalita* ; MAL.—*Nalugu, nellu* ; ORIYA —*Hatikanopotro.*

KHASI—*Soh-phyrnou-nar* ; GARO—*Gangma-chhan-goppa.*

A perennial undershrub, up to 2.5 m. in height, with conspicuously winged stems, found in north-eastern India and in the western parts of Deccan Peninsula. Leaves pinnate, 3–5 foliolate: leaflets oblong-lanceolate ; flowers in corymbose cymes, whitish or pale yellow ; berries depressed-globose, dark grey or black when ripe. The plant grows gregariously in Assam and is reported to help the regeneration of sal by ousting grass and preparing the soil for seed germination (Fl. Assam, I, 306).

The berries are eaten. Root tubers are used for guineaworm and leaves are applied to wounds. *L. crispa* is a host plant of the Indian lac insect [Carter & Carter, *Rec. bot. Surv. India,* 1921, **6**(9), 394 ; Kirt. & Basu, I, 618 ; Glover, 137].

L. indica Merrill syn. *L. sambucina* Willd. (Fl. Br. Ind.) in part

D.E.P., IV, 618 ; Fl. Br. Ind., I, 666 ; Kirt. & Basu, Pl. 256.

HINDI & BENG.—*Kurkur-jihwa* ; MAR.—*Dino, karkani* ; TEL.—*Ankadosa* ; TAM.—*Nalava, nyekki, ottanali* ; KAN.—*Andilu* ; MAL.—*Erattayani, maniperandi* ; ORIYA—*Bonotulasi.*

ASSAM—*Kukurathengia.*

A handsome shrub or a small tree with tough branches, sometimes developing aerial roots, distributed almost throughout India, from Garhwal eastwards to Assam and southwards to Kerala ; it is found also in Andaman Islands. Leaves 2–3 pinnate: leaflets elliptic-oblong ; flowers in corymbose cymes, whitish ; berries depressed-globose, purple-black.

The tender shoots of the plant are used as vegetable ; fruits are also edible. Leaves are used as green manure. The large pith of stem and branches is often used as a substitute for Elder pith (from *Sambucus* spp.) in biological laboratories. The roots are used in diarrhoea, colic, dysentery and as sudorific. They are covered with dark brown, striated bark with an astringent, rather agreeable flavour. The leaves are roasted and applied to the head in vertigo [Fl. Assam, I, 307; Rama Rao, 93 ; Santapau, *Rec. bot. Surv. India*, 1953, **16** (1), 55 ; Dymock, Warden & Hooper, I, 364 ; Kirt. & Basu, I, 619].

L. macrophylla Roxb.

D.E.P., IV, 617 ; Fl. Br. Ind., I, 664 in part ; Kirt. & Basu, Pl. 254.

HINDI & BENG.—*Dholsamudra* ; MAR.—*Dinda.*

U.P.—*Hathikana* ; NEPAL—*Bulevttra* ; SANTAL—*Hatkan* ; LEPCHA—*Dampamtom-kung* ; KHASI—*Pharun-barne.*

A herb, 90 cm. or more in height, with switchy branches and perennial tuberous roots, distributed throughout the hotter parts of India. Leaves simple, ovate-cordate, conspicuously large (lower leaves up to 60 cm. diam.) ; flowers in corymbose cymes, whitish ; berries depressed-globose, black.

The leaves of the plant are eaten as vegetable ; they are also used as platters. Fruits are edible. Root tubers are deep red in colour, mucilaginous and astringent, and are credited with anodyne properties. They are applied to wounds and sores and used for guineaworm and ringworm (Fl. Assam, I, 305 ; Kirt. & Basu, I, 617 ; Rama Rao, 92).

L. robusta Roxb. syn. *L. diffusa* M. Laws.

D.E.P., IV, 618; Fl. Br. Ind., I, 667; Kirt. & Basu, Pl. 257.

TEL.—*Peddapayagillaku*; ORIYA—*Nunonunia*.

NEPAL—*Galeni*; LEPCHA—*Pantom*; LUSHAI—*Koulkar*; SANTAL—*Haramada*.

A large handsome shrub, found from Sikkim to Assam up to an altitude of 1,500 m. and in Bengal, Bihar, Orissa and Deccan Peninsula; it is found also in Andaman Islands. Leaves 2–3 pinnate: leaflets elliptic-oblong; flowers in corymbose cymes, greenish or bluish; berries depressed-globose, black when ripe.

The roots are soft and fleshy and are externally applied for allaying pain. They are used in dysentery and given to cattle in diarrhoea. The wood is brown and moderately hard and used in the construction of huts, fences and stakes; dried stems are used as torches. The tree is a host of the Indian lac insect (Kirt. & Basu, I, 620; Gamble, 191; Glover, 137).

L. acuminata Wall. ex C. B. Clarke syn. *L. sambucina* M. Laws. (Fl. Br. Ind.) in part (NEPAL—*Lalgaleni*; ASSAM—*Bajiou, kath-thengia*) is a handsome undershrub with red or purple flowers and orange red fruits, found in eastern Himalayas, Assam, Orissa and Andaman Islands. The stems are used for the construction of huts (Fl. Assam, I, 305).

L. edgeworthii Santapau syn. *L. aspera* M. Laws. (Fl. Br. Ind.), non Wall. ex Roxb. (PUNJAB—*Kumala, holma*; KUMAON—*Kumali*; JAUNSAR—*Kawa okhar*; KHASI—*Soh-phyrnou*; MADHYA PRADESH—*Kurani chirpali*) is an undershrub with 1–2 pinnate leaves and black berries found scattered almost throughout India, ascending up to 1,300 m. in the Himalayas. Fruits, leaves and roots are edible; it is a host plant of the Indian lac insect (Witt, 54; Krishnaswami & Saikia, *Indian For.*, 1959, **85**, 204).

L. umbraculifera C. B. Clarke (ASSAM—*Ahina, gach-gangma*) and *L. bracteata* C. B. Clarke (LUSHAI—*Kumtin-toi*; KHASI—*Lang-kurnu*) are shrubs or small trees found in eastern Himalayas and Assam. The wood of these species is ornamental (Fl. Assam, I, 307–08).

Some species of *Leea* are ornamental and are valued for their foliage and fruit (Firminger, 586; Gopalaswamiengar, 340).

LEECHES (Phylum *Annelida*, class *Hirudinea*)

D.E.P., IV, 619; Fn. Br. Ind., Hirudinea, 1927.

SANS.—*Raktapa, jalauka, jala-sarpini*; HINDI—*Jalu, jok, jonk*; BENG.—*Jonk*; GUJ.—*Jala*; TEL.—*Jalagalu, attalu, jeriku*; TAM.—*Attai*; KAN.—*Jiganey*; MAL.—*Atta*.

KASHMIR—*Drik*.

Leeches are carnivorous or blood sucking annelid worms with pronounced ability to extend or contract their bodies. They are distributed all over the world, except the polar zones, deserts and altitudes exceeding 3,700 m. About 45 species belonging to 22 genera occur in India.

Leeches may be aquatic, amphibious or terrestrial. They vary in length from a few mm. to 30 cm. or more. At each end of the body there is a sucker, the mouth being within that of the anterior end. It progresses by means of suckers, looping the body like a measuring worm or swimming with an undulating movement. Leeches are hermaphrodite. In the majority of forms, fertilization is effected by hypodermic impregnation. Eggs are laid in cocoons secreted by the clitellum, which remain attached to any submerged foreign body or lodged in bank-side burrows. The development is direct without any intermediary larval stage. Leeches are active during the months of the monsoon and are known to hibernate in severe winter, burying themselves in mud. They reappear in spring, which is the time for breeding.

Most of the leeches are permanent or temporary external parasites, attaching themselves to the host and sucking the blood. The anterior sucker, jaws and muscular pharynx serve as an efficient apparatus for the abstraction of blood. Sucked blood is stored in lateral diverticulae of the crop and as the blood passes down the pharynx, it is mixed with a glandular secretion which prevents its coagulation. A leech ingests at a single meal several times its own weight of blood which may suffice for several months (Encyclopaedia Britannica, XIII, 866; Pycraft, 51–53; Matthai, *J. Asiat. Soc. Beng., N.S.*, 1920, **16**, 341; Bhatia, *Indian zool. Mem.*, 1941, **8**; Brookeworth, *J. Bombay nat. Hist. Soc.*, 1951–52, **50**, 423; Harrison, ibid., 1952–53, **51**, 959; 1954–55, **52**, 468; Champion Jones, ibid., 1954–55, **52**, 650; Sykes, ibid., 1955–56, **53**, 148).

The commonly known leeches of India belong to the genera *Hirudinaria* Whitman, *Haemadipsa* Tennent, *Hirudo* Linn. and *Dinobdella* Moore. They thrive in situations where moist humus abounds and are known to be plentiful in rain forests up to an altitude of 2,500 m. They are also common in tea-growing areas, humid grazing lands, shrubby undergrowths, rice fields, swamps, buffalo wallows and ponds.

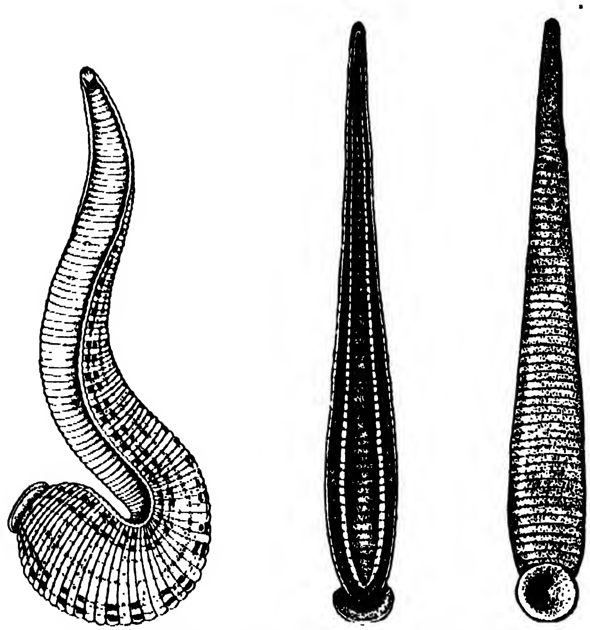


FIG. 23. LEECHES—HIRUDINARIA GRANULOSA (×½); HAEMADIPSA ORNATA, DORSAL AND VENTRAL VIEWS (×1½)

Leeches are a great nuisance to man and livestock. Stubborn sores, sometimes leading to crippling, may result from their bites. *Hirudinaria granulosa* (Savigny) often attacks human beings and is troublesome to those engaged in construction work in swampy areas. *H. javanica* (Wahlberg) and *H. manillensis* (Lesson) are a nuisance both for human beings and cattle. Leeches belonging to the genus *Haemadipsa* are particularly troublesome because of their teeming abundance; their wide dissemination is due to their attaching themselves to birds. *Haemadipsa zeylanica* Moquin-Tandon, *H. sylvestris* Blanchard, *H. ornata* Moore (Sans.—*Indrayudha*) and *H. montana* Moore are the common species found in India. *H. ornata* has been recorded from the hill tracts of Assam: its bite, unlike that of other leeches, is painful: it may sometimes prove fatal as the leech carries septic bacteria. The capacity of *H. montana*, occurring in Palni hills and near Darjeeling, for imbibing blood is said to be phenomenal. *Hirudo birmanica* (Blanchard) attacks human beings and probably also domestic and wild animals. *Dinobdella ferox* (Blanchard) (Sans.—*Shabarika*), the notorious cattle leech, is widely distributed in India and is particularly abundant in Assam, Punjab and Uttar Pradesh up to an altitude of 2,300 m. It attacks domestic animals by attaching itself in large numbers to the walls of the buccal chamber, nasal passages, pharynx and larynx of the victim; the affected animal becomes emaciated and may even die. Both land and aquatic leeches act as intermediate hosts in the dissemination of some blood and skin diseases.

Boots stuffed with tobacco leaves and ankle putties treated with nicotine sulphate solution are often used as protection against leeches by persons living in tropical rain forest and plantation areas. Insect repellents, like dimethyl phthalate, dibutyl phthalate, benzyl benzoate and 2-ethylhexanediol, give protection for 2–3 hours. Smearing of exposed parts with an ointment of 1 part of cinnamon oil and 7 parts of vaseline is temporarily effective. A paste containing pyridine and bees wax in hot castor oil or melted petroleum jelly affords protection for a number of days when smeared on exposed parts. A new U.S. Army repellent, M-1960, used for impregnating clothes against mites, mosquitoes and fleas, is also effective against land leeches (Brookeworth, *J. Bombay nat. Hist. Soc.*, 1951–52, **50,** 423; Smythies, ibid., 1952–53, **51,** 954; Williams, ibid., 1954–55, **52,** 652; Sykes, loc. cit.; Narasimhan & Thirumalachar, *Curr. Sci.*, 1945, **14,** 342; *Indian For.*, 1946, **72,** 173; Traub *et al.*, *Nature, Lond.*, 1952, **169,** 667; Harrison, *J. Bombay nat. Hist. Soc.*, 1954–55, **52,** 468; Bailey, ibid., 1954–55, **52,** 652; Mathews, ibid., 1954–55, **52,** 655).

Leeches have been used medicinally for phlebotomy and production of an anticoagulant. They were once used in India and elsewhere for the abstraction of blood from foul ulcers and other congested parts of the body, but the practice, except in some villages, is no longer prevalent. *Hirudinaria* (*Poecilobdella*) *granulosa* (Savigny) (Sans.—*Alagarda*), abundant in the States of Madras, Kerala, Madhya Pradesh, Uttar Pradesh and the Punjab, was the species commonly cultured for this purpose. The leech is bred in earthen pots containing moistened clay. After the leech sucks the blood and drops off, it is made to disgorge the blood by pressing it between fingers or by dipping in saline or camphor water. The disembogued leech is fit for reuse.

The buccal secretion of leeches contains an active principle, hirudin, which retards the coagulation of blood. Hirudin is extracted from leeches by normal saline at 38°–40°; each leech is reported to yield up to 3 mg. of the active principle. Hirudin is employed as an anticoagulant in surgical operations and has been recommended for the prevention of phlebitis and post-operative pulmonary inflammations. Commercial samples of hirudin have sometimes been found to be toxic, perhaps due to putre-

faction. Leech extract is reported to be efficacious in the treatment of asthma, acute rhinopharyngitis and spasmodic coryza. It contains a mucolytic enzyme (Merck Index, 497 : U.S.D., 1955, 1735 ; B.P.C., 1954, 412 ; *Chem. Abstr.*, 1940, **34,** 4397 ; 1953, **47,** 2372).

Leeches and their cocoons are eaten by ducks, other birds and certain types of fishes. Some predaceous leeches destroy harmful invertebrates and insect larvae, and exert a repressive influence on rodent population.

Leek — *see* **Allium**

LEERSIA Sw. (*Gramineae*)

A small genus of aquatic grasses occurring in the tropical and sub-tropical regions of both hemispheres. About three species occur in India of which one is of fodder value.

L. hexandra Sw. Syn. *Homalocenchrus hexandrus* Kuntze RICEGRASS

D.E.P., IV, 619 ; Fl. Br. Ind., VII, 94 ; Blatter & McCann, 272, Pl. 185.

HINDI—*Jangli dhan* ; KAN.—*Kadu bili sajjabu hullu* ; MAL.—*Nir valli pullu.*

ASSAM—*Arail, arali.*

A rice-like, aquatic, perennial grass with extensively creeping leafy rhizomes, found all over India in swampy and marshy areas, from sea level up to 2,100 m. Leaves erect, flat, rigid, acuminate ; panicles branching, few-flowered, 5–10 cm. long. The grass frequently forms a dense mass in paddy fields, and margins of lakes and swamps. During the dry period, it creeps on the ground sending out long runners. It yields a useful green forage and is cultivated in some parts of the world in the same way as rice. Yields up to 12,200 kg. (12 tons) per acre have been obtained by intensive farming (Fl. Assam, V, 173 ; Das, *Bull. Dep. Agric. Assam,* No. 10, 1939 ; Ranga Achariyar, 125 ; Burkill, II, 1328 ; Loosli *et al., Philipp. Agric.*, 1954–55, **38,** 73).

L. hexandra affords good forage when cut early and is esteemed as one of the best fodder grasses in Australia. It is relished by horses and cattle and may be used both as green feed and hay. Analysis of green grass at the flowering stage gave the following values (dry basis): crude protein, 5.83 ; ether extr., 2.1 ; crude fibre, 28.4 ; N-free extr., 47.0 ; ash, 16.7 ; calcium, 0.19 ; and phosphorus, 0.14% ; *digestibility co-efficient* (av. value): dry matter, 48 ; crude protein, 40 ; ether extr., 23 ; crude fibre, 63 ; and N-free extr., 54%. In nutritive value, the green material is comparable to the commonly cultivated fodder plants. When turned into hay, the grass retains the green colour and is considerably softened. Adult animals maintained on green grass or hay showed a positive nitrogen balance ; calcium and phosphorus balances were negative (Talapatra, *Indian J. vet. Sci.*, 1950, **20,** 229 ; Loosli *et al.*, loc. cit.).

The leaves and stems of the grass contain traces of hydrocyanic acid (Quisumbing, 1023).

LEMNA Linn. (*Lemnaceae*)

D.E.P., IV, 620 ; Fl. Br. Ind., VI, 556.

A genus of floating aquatic herbs, commonly known as Duckweeds, distributed throughout the world, chiefly in temperate and warm regions. Four species are found in India.

Duckweeds occur gregariously, often forming a green mantle on the surface of ponds, lakes and other still waters or sluggish streams. They are sometimes introduced into aquaria and lawn basins. The plant body consists of minute thalli or fronds, each bearing a single root on the under surface. Reproduction is generally by vegetative budding. Duckweeds perennate during winter by specialized buds which sink to the bottom and plants reappear in summer and rainy season (Biswas & Calder, *Hlth Bull.*, No. 24, 1954, 98–100).

Among the Indian species, *L. minor* Linn. (COMMON DUCKWEED) and *L. paucicostata* Hegelm. =*L. perpusilla* Torr. are reported to occur in many parts of the country. The fronds in both are 3–6 mm. long, variable, obovoid, obovate or oblong ; they are more asymmetrical in *L. paucicostata* than in *L. minor.* Both are capable of thriving in foul waters, not conducive to the growth of other floating plants, and cleanse them of organic impurities. Water birds, specially ducks, and some fishes feed on the plants. In Bengal, some fish farmers introduce *L. minor* in carp nurseries as it destroys algae and promotes the growth of zooplanktons. Mosquito larvae are usually rare in ponds with a surface screen of lemnas [McCann, *J. Bombay nat. Hist. Soc.*, 1942–43, **43**(2), 148 ; Biswas & Calder, *Hlth Bull.*, No. 24, 1954, 99 ; Alikunhi *et al.*, *Sic. & Cult.*, 1951–52, **17,** 436 ; Chittenden, III, 1146].

Duckweeds occasionally become pests in garden ponds and fields. *L. minor* is reported to infest flooded rice fields causing damage to the crop. Application of the leaves and twigs of *Adhatoda vasica* Nees as green manure is reported to eradicate the pest. Spraying with pentachlorophenol solution (1 in 750–

1 in 1,000) at the rate of 250 litres per acre for 2–3 days destroys the pest; 0.1% methoxone has also been tried with satisfactory results (*Chem. Abstr.*, 1955, **49**, 14256; Kar, *Sci. & Cult.*, 1946–47, **12**, 545).

Duckweeds are recommended for use as manure. Some species have been employed as test plants for the rapid determination of herbicidal effect of chemicals and in the study of trace element requirements of crop plants. They are capable of accumulating radium and mesothorium-I from the surrounding water (*Chem. Abstr.*, 1930, **24**, 5773; 1937, **31**, 7941; 1947, **41**, 3246; Steinberg, *J. agric. Res.*, 1941, **62**, 423).

Duckweeds are reported to possess cooling, astringent and diuretic properties and are used for cutaneous diseases and as wash for ophthalmia. *L. minor* is employed in homeopathy (Steinmetz, II, 270).

Lemon — *see* **Citrus**

Lemongrass — *see* **Cymbopogon**

LENS Mill. (*Leguminosae*)

A small genus of erect or sub-erect annual herbs, distributed mainly in the Mediterranean region and western Asia. One species is widely cultivated in India for its seeds used as food.

L. culinaris Medic. syn. *L. esculenta* Moench; *Ervum lens* Linn. LENTIL

D.E.P., IV, 621; C.P., 708; Kirt. & Basu, I, 741.

HINDI, BENG., MAR. & GUJ.—*Masur, masser, masuri;* TEL.—*Misurpappu, chirisanagalu;* KAN.—*Massur, chanangi.*

PUNJAB—*Masur, malka masur, musri;* ASSAM—*Masurmoha.*

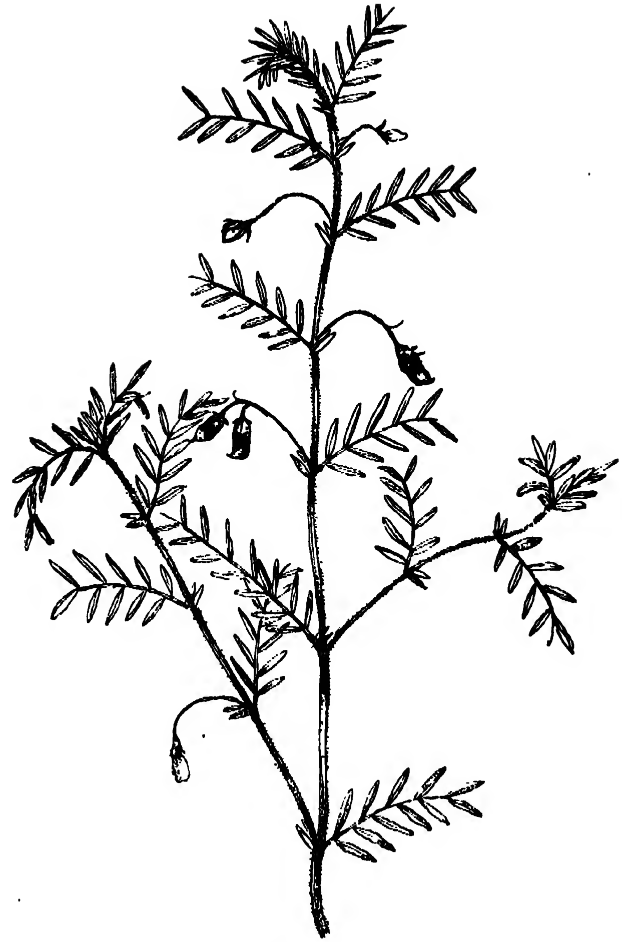


FIG. 24. LENS CULINARIS—FRUITING BRANCH

A small, erect, softly pubescent herb, 15–75 cm. high, with compound leaves and white, rose, red or violet flowers borne solitarily or in 2–4 flowered racemes; pod smooth, compressed, oblong or rhomboid, 1–1.5 cm. long, containing two smooth, compressed, lenticular seeds, varying in colour from pale pinkish buff to prussian red.

Lentils have been valued as an article of food from biblical times. It is widely grown in the Mediterranean countries, particularly in Spain, France, Italy and Greece in Europe, Morocco, Algeria, Egypt and Ethiopia in N. Africa, Jordan, Syria and Turkey in Middle East. India and Pakistan are, however, the major producers at present. In recent years it is being grown also in Argentina, Ecuador and Chile (Table 1). Its cultivation in India is quite ancient. It is grown throughout N. India, particularly in Uttar Pradesh, Madhya Pradesh, Bihar and West Bengal and to a smaller extent in Punjab, Rajasthan, Maharashtra and Gujarat. It is not an important pulse crop in S. India. Table 2 summarizes the available data on acreage and production of lentil in India [Mann, *Emp. J. exp. Agric.*, 1947, **15**, 249; Whyte *et al.*, 283; Dutt & Pugh, 323; Yegna Narayan Aiyer, 138; Mehta, *Agric. Anim. Husb., Uttar Pradesh*, 1955–56, **6**(2–3), 3].

Lentil is considered to be a native of Asia Minor, Persia or possibly Hindu Kush. Wild relatives of the cultivated species are recorded mostly in central and west Asian regions and a few from the Mediterranean region and Abyssinia. They have been classified under two sub-species, *macrospermae* and *microspermae*, the former comprising the large seeded forms of the Mediterranean and African regions, and

TABLE 1—ACREAGE AND PRODUCTION OF LENTIL IN IMPORTANT COUNTRIES*

	Area (thousand acres)				Production (thousand tons)			
	1948–52 (av.)	1956	1957	1958	1948–52 (av.)	1956	1957	1958
India	1,406	1,223	1,287	1,260	286	205	188	175
Pakistan	385	400	420	368	93	91	92	79
Ethiopia	n.a.	n.a.	n.a.	n.a.	74	74	63	62
Syria	143	210	230	294	38	74	76	35
Turkey	126	198	203	205	49	51	72	69
Spain	119	101	106	104	21	25	29	28
Egypt	74	86	86	77	44	47	52	41
Algeria	82	54	32	40	16	12	7	8
Italy	62	64	64	59	13	13	17	17
Jordan	37	57	59	62	8	22	12	4
France	37	35	30	32	9	11	8	12
Greece	32	47	47	40	7	13	15	10
Iraq	25	35	32	32	6	10	8	3
Morocco	40	25	27	n.a.	6	4	4	n.a.
Argentina	62	32	47	32	25	6	6	4
Chile	47	47	52	69	14	12	13	14
Ecuador	20	22	20	30	5	10	9	9
Total (excluding U.S.S.R.)**	3,484	3,113	3,237	3,212	748	699	699	590

* *Production Yearb. FAO*, 1959, **13**, Table 32.
** Includes data for countries not included above and also estimates where figures are not available.

TABLE 2—ACREAGE AND PRODUCTION OF LENTIL IN INDIA*

					Production (thousand tons)			
	Av. for triennium ending 1956–57**	1957–58	1958–59	1959–60	Av. for triennium ending 1956–57**	1957–58	1958–59	1959–60
Assam	9.0	9	11	11	1.0	1		
Bihar	336.7	306†	369†	330†	62.1	44†	54†	64†
Madhya Pradesh	437.0	434	547	549	67.5	54	93	95
Maharashtra & Gujarat	25.0	17	21	31	3.0	2	3	4
Mysore	6.5	4	5	5	1.0	1	@	@
Orissa	7.9	n.a.	n.a.	n.a.	1.6	n.a.	n.a.	n.a.
Punjab	115.5	146	169	208	24.0	30	36	43
Rajasthan	19.5	22	27	28	3.0	4	5	8
Uttar Pradesh	373.0	433	499	481	58.5	57	80	75
West Bengal	253.0	193	249	255	37.0	26	29	47
Himachal Pradesh	3.0	3	3	4	@	@	1	1
Total	1,586.1	1,567	1,900	1,902	258.7	219	303	338

* Data from Directorate, Econ. & Statist., Ministry of Food & Agric. Govt. India. ** *Marketing of Pulses in India, Marketing Ser* No. 102, 1958, 175 77. † Data from Directorate of Statistics, Govt. Bihar. n.a. not available. @ Less than 500 tons.

the latter yielding comparatively small seeds and found in western and south-western parts of Asia. The latter is further sub-divided into geographical races, viz. Afghanistan, Indian (endemic), north-east African, south-west and western African, western European and western Asian races. The two sub-species though having the same chromosome numbers (n=14), produce sterile hybrids when crossed with each other. A variety, var. *himalayaensis* Thellung, occurring in Nepal is resistant to snout moth (*Etiella zinckenella* Tr.) (Vavilov, 31, 32, 35, 38, 151; Darlington & Wylie, 155; Mann, loc. cit.; Hector, II. 648; Kitamura in Kihara, II, 120).

Lentils show a wide range of variation in the colour of flowers and the type of pods and seeds borne by them. Though self-fertilization is the general rule, cross-fertilization is often probable. The seeds are bold, intermediate or small and have a ground colour which may be Prussian red, salmon buff, vinaceous buff, vinaceous pink, buff pink or pale pinkish buff. The majority of seeds possess markings over the ground colour. The markings are in the form of cloudy mottling or sky-grey specklings and may be sparse, medium or heavy; they are generally confined to testa only (Shaw & Bose, *Mem. Dep. Agric. India, Bot.*, 1928, **16**, 159).

Associated with the size and colour of the seed are variations in the adaptability of types to soil and climatic conditions. Types grown in the black cotton soils of India generally have a deep root system, while those of the alluvial soil have a branched shallow root system with abundant root nodules; plants of dry regions, like those of Punjab, have a root system which is intermediate between the two. Plants with deep penetrating roots show sparse branching and give a poor yield of bold seeds, while those with shallow roots have a profusion of branches and give high yields of small seeds (Shaw & Bose, loc. cit.).

Two types of lentil are commonly recognized in the Indian trade; bold seeds known as Masur or Malka Masur and small seeds known as Musri. A similar distinction is recognized in Europe and other countries. Egyptian lentil is generally bold and so also lentil types grown in S. America; European types are usually small. About 66 pure types of lentil have been isolated from seeds collected from different places in India. They vary from one another in (*i*) size, colour and markings of seed, (*ii*) colour of flower, (*iii*) time of flowering, (*iv*) habit, (*v*) colour of leaf and (*vi*) colour of stem. Out of the 66 types, *N.P. 11* and *N.P. Hybrid 1* have been selected for distribution. In Uttar Pradesh, *Type 3*, a selection from Agra, gives high yields (1,300–1,500 lb./acre); this type has been replaced by *Type 36*, a superior selection giving higher yield, 1,960 lb./acre. In Bombay, two selections, *No. 15* and *No. 20*, isolated from local types have given 20–25% higher yield in Nasik district [Roberts & Kartar Singh, 292; Shaw & Bose, loc. cit.; *Colon. Pl. Anim. Prod.*, 1952–53, **3**, 254; *Sci. Rep. agric. Res. Inst. N. Delhi*, 1949, 29; *Annu. Rep. Indian Coun. agric. Res.*, 1953–54, 40; Singh, *Agric. Anim. Husb., Uttar Pradesh*, 1955–56, **6**(2–3), 60; Dharampal Singh, *Tech. Bull. Bur. agric. Inform. Uttar Pradesh, N.S.*, No. 1, 1957, 11; Chavan & Shendge, *Poona agric. Coll. Mag.*, 1957–58, **48**(2–3), 78].

Cultivation—Lentil shows a wide range of adaptation to climatic conditions. In India, it is grown in situations up to a height of 3,450 m. and on a variety of soils, such as light loam and alluvial soils of N. India and black cotton soils of Peninsular India. It is also grown in low-lying (*sailaba*) lands in Punjab and is usually the first crop sown on new alluvial lands just recovered from the river. It tolerates moderate alkalinity. In rich soils with too much moisture, the plants produce a profusion of leaf and the yield of pods and seeds is poor (Mann, loc. cit.; Whyte *et al.*, 283; Roberts & Kartar Singh, 292; Yegna Narayan Aiyer, 138).

Not much of cultivation is given to lands sown with lentil. In Punjab and U.P., where it is mainly grown in low-lying lands after a crop of rice, only one or two ploughings are given. In the case of black cotton soils, the land is ploughed soon after the monsoon and brought into a rough tilth by working with blade harrows. Sowing is usually done in October–November along with other rabi crops; it can be sown even later, up to January. Seeds are sown broadcast or in rows 22–30 cm. apart; the seed rate varies from 20 to 80 lb. per acre depending upon whether it is sown pure or in admixture with other crops, like barley, mustard or castor. The crop receives little further attention and is ready for harvest in about 3½ months. Plants are cut down to the ground level or pulled out and stacked. They are threshed after drying. The yield of seeds ranges from 300 to 600 lb. per acre when grown mixed or under dry cultivation, and from 800 to 1,000 lb. when sown pure on irrigated land. Under favourable conditions yields up to 1,400–1,500 lb. per acre are possible. In Egypt, where large seeded types are grown under basin irrigation, a yield of 1,500 lb. per acre has been

reported (Dutt & Pugh, 324; Roberts & Kartar Singh, 292; Yegna Narayan Aiyer, *Indian J. agric. Sci.*, 1949, **19,** 439; Yegna Narayan Aiyer, 138–39; *Agric. Marketing India, Marketing of Pulses in India, Marketing Ser.*, No. 102, 1958, 109; Mehta, *Agric. Anim. Husb., Uttar Pradesh*, 1955–56, **6**(2–3), 7; *Colon. Pl. Anim. Prod.*, 1952–53, **3,** 254).

Diseases & Pests—The crop is not subject to any serious diseases or pests. A leaf rust [*Uromyces fabae* (Pers.) de Bary] has been reported to cause slight damage. Burning of plant debris after harvest and treatment of seeds have been suggested as control measures. A wilt disease [*Fusarium orthoceras* (App. et Wr.) var. *lentis* Vasudeva & Srinivasan] has also been reported. *Vicia* sp. (Vetch), which is similar to lentil in appearance, often occurs as a weed in lentil fields; it is sometimes a serious pest and in such cases the quality of lentil crops are seriously affected by the presence of weed seeds (Dutt & Pugh, 324; Prasada & Verma, *Indian Phytopath.*, 1948, **1,** 142; Vasudeva & Srinivasan, ibid., 1952, **5,** 23; Shaw & Bose, loc. cit.).

Uses—Lentil is mostly used as *dhal* (dehusked grain). For removing the husk, the seed is moistened with oil and water, dried in shade and passed through a mill 2 or 3 times. Everytime the *dhal, chooni* (broken bits) and husk are separated. To give an attractive appearance, the husked pulse is polished with magnesite powder and gritty powder (Dharampal Singh, loc. cit.; *Marketing of Pulses in India*, 1958, 70).

Lentil is used mainly in soups flavoured with spices and condiments, and also as a component of *kichri*. Young pods are eaten as vegetable. Lentil meal, mixed with barley or other cereal flour and common salt, is marketed as invalid food in some countries. In Uttar Pradesh, fairly large quantity of whole seed is used in preparing *dal-mot*, a salted fried preparation (Niyogi *et al.*, *Indian J. med. Res.*, 1931–32, **19,** 859; *Marketing of Pulses in India*, 1958, 21).

Composition—The pulse sold in India shows considerable variation in size and cooking quality, depending upon the region from which it has been obtained. Analytical data for different types are not available. The following values have been reported for a bazaar sample from Coonoor: moisture, 12.4; protein, 25.1; fat (ether extr.), 0.7; carbohydrates, 59.7; and mineral matter, 2.1%. The carbohydrates present are hemicellulose, starch, *para*galactoaraban, stachyose and reducing sugars (*Hlth Bull.*, No. 23, 1951, 30; Thorpe, VII, 275).

Lentils are valued for their high protein content. Strain *N.P. 11* yields seeds containing as much as 30% proteins. Lentil proteins are similar to those of peas and beans. Partition of total proteins gave the following fractions: water sol., 25.9; globulin, 44.0; prolamin, 1.8; and glutelin, 20.6%. The water soluble fraction consisted mostly of non-protein nitrogen: the presence of two proteoses is reported. The principal protein of lentil is globulin; analysis of a sample (N, 15.92%) gave the following nitrogen distribution values: sol. humin N, 1.40; insol. humin N, 0.40; amide N, 6.48; diamino N (arginine, 12.58; histidine, 2.22; lysine, 13.75), 28.55; monoamino N, 27.41; and non-amino N, 34.90%. Nitrogen distribution in glutelin (N, 13.65%) is as follows: sol. humin N, 2.12; insol. humin N, 2.17; amide N, 11.4; diamino N (arginine, 9.93; histidine, 0.96; cystine, 0.84; lysine, 10.44), 21.57; monoamino N, 52.0; and non-amino N, 10.09% (Jacobs, I, 212; Gupta & Das, *Ann. Biochem.*, 1955, **15,** 75; Basu *et al.*, *Indian J. med. Res.*, 1936–37, **24,** 1027).

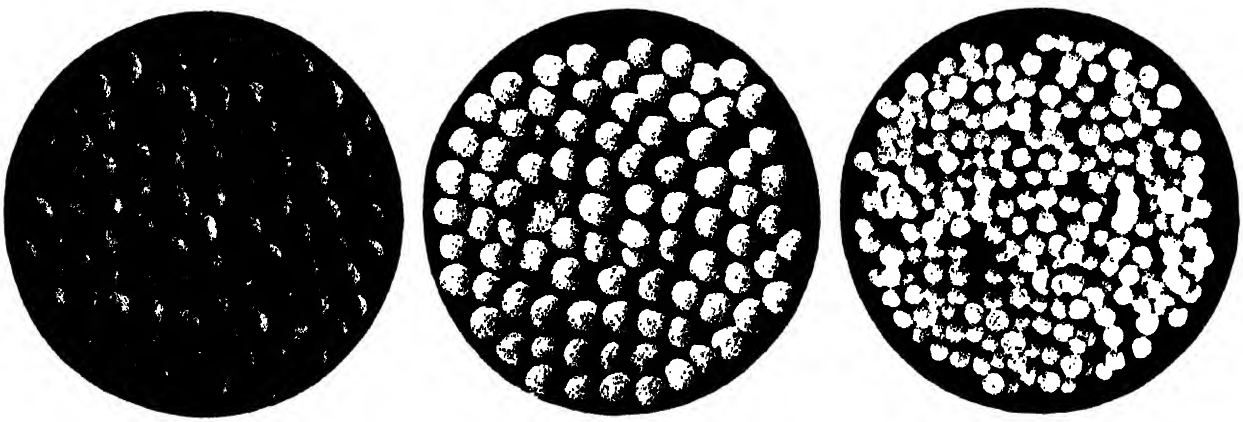


FIG. 25. LENS CULINARIS—SEEDS: UNHUSKED, DEHUSKED, AND BROKEN

The biological value and digestibility coefficient of lentil proteins at different levels of protein intake are given in Table 3. Table 4 gives the essential amino acids present in the total proteins. The proteins are deficient in methionine and tryptophan and the protein efficiency ratio increases from 0.7 to 2.6 by supplementing lentil with a combination of methionine tryptophan and threonine. Germination of the pulse raises the biological value of the proteins. Autoclaving also improves the protein quality. The presence of a trypsin inhibitor in lentil has been reported; it is heat labile and does not appear to influence the nutritive value of germinated or autoclaved material. In nutritive value, lentil occupies a place second only to Bengal gram (*Cicer arietinum*) and black gram (*Phaseolus mungo*) among the pulses commonly consumed in India (Kuppuswamy *et al.*, 36; *Nutr. Abstr. Rev.*, 1955, **25,** 29; Chattopadhyay & Banerjee, *Indian J. med. Res.*, 1953, **41,** 185; Sohonie & Bhandarkar, *J. sci. industr. Res.*, 1955, **14C,** 100; *Food Sci. Abstr.*, 1952, **24,** 381; Pal, *Indian J. agric. Sci.*, 1939, **9,** 133).

In common with other pulses, lentil is a good source of vitamins of the B group; it contains: thiamin, 0.26; riboflavin, 0.21; nicotinic acid, 1.7; choline, 223; folic acid, 107; inositol, 130; pantothenic acid, 1.6; biotin, 13.2; and pyridoxin, 0.49 mg./100 g. Other vitamins reported to be present are: carotene, 1.6; ascorbic acid, 4.2; vitamin K, 0.25; and tocopherol, 2.0 mg./100 g. There is a marked increase in vitamins, except folic acid and pantothenic acid, during germination (Chattopadhyay *et al.*, *Indian Pharm.*, 1949–50, **5,** 121; Nandi & Banerjee, ibid., 1949–50, **5,** 13, 63, 202; Chattopadhyay & Banerjee, *Food Res.*, 1951, **16,** 230; 1952, **17,** 402; Banerjee *et al.*, ibid., 1954, **19,** 134; 1955, **20,** 545; Chattopadhyay & Banerjee, *Science*, 1951, **113,** 600).

TABLE 3—BIOLOGICAL VALUE AND DIGESTIBILITY CO-EFFICIENT OF LENTIL PROTEINS

Level of protein intake (%)	Biological val. (%)	Digestibility co-efficient (%)
6*	53	92
11*	32	90
15*	25	92
10†	58	78
10‡	41	88
12§	45	92

* Basu *et al.*, *Indian J. med. Res.*, 1935–36, **23,** 789; † Niyogi *et al.*, ibid., 1931–32, **19,** 859; ‡ Swaminathan, ibid., 1936–37, **24,** 767; § Esh & Som, *Indian J. Physiol.*, 1952, **6,** 61.

TABLE 4—ESSENTIAL AMINO ACIDS PRESENT IN LENTIL PROTEINS*
(expressed in g./16 g. N)

	1	2	3	4	5†
Arginine	..	7.0	..	..	8.5
Histidine	..	2.1	..	13.5	1.7
Methionine	0.7	0.8	0.6	0.7	0.5
Lysine	6.4	5.8	5.1	11.6	7.4
Valine	5.0	5.4	5.1	5.6	5.7
Phenylalanine	4.5	4.1	4.0	5.3	3.7
Tryptophan	0.8	0.3	0.6	1.6	0.3
Leucine	6.9	5.4	5.5	..	8.5
Isoleucine	4.5	5.4	5.8	..	6.5
Threonine	3.5	2.9	3.0	5.0	3.9

* Kuppuswamy *et al.*, 48; † Chatterjee *et al.*, *Food Res.*, 1956, **21,** 569.

The mineral constituents reported in lentil are the following: calcium, 38.6; phosphorus, 242.0; iron, 7.62; sodium, 36.0; potassium, 673; magnesium, 76.5; sulphur, 122.0; and chlorine, 63.6 mg./100 g.; iodine (25–30 μg./kg.), bromine, manganese, aluminium, copper, zinc and arsenic are also present. Available iron (2.20 mg./100 g.) increases during the germination of the pulse. The distribution of phosphorus (0.381%) in dried lentil is reported to be as follows: lipoidal, 0.046; nuclein, 0.043; phytin, 0.192; and mineral, 0.1%. Calcium magnesium inositol phosphates are present to the extent of 0.52% in fat-free lentils (McCance & Widdowson, 87; Thorpe, VII, 275; Iodine Content of Foods, 92; Singh & Banerjee, *Indian J. med. Res.*, 1955, **43,** 497; *Chem. Abstr.*, 1932, **26,** 2488, 2767; 1934, **28,** 2747).

Lentil contains amylase (optimum *p*H, 6.25), proteolytic enzymes, phosphatase and phytase. The germinating plant shows high dipeptidase activity. A saponin, named esculenin (m.p. 173–75°), has been isolated in appreciable amounts. Asparagin is present in the embryo (Wehmer, I, 557–58; Belavady & Banerjee, *Food Res.*, 1953, **18,** 223; Biswas, *Sci. & Cult.*, 1943–44, **9,** 165, 252; *Chem. Abstr.*, 1940, **34,** 5116; 1942, **36,** 6173).

Starch—Lentil may be used as a source of commercial starch (yield, 28.5%) for use in textile and calico printing industries. The starch obtained resembles maize starch in grain size (3.9–15.7μ × 9.8μ) and general appearance. Its viscosity remains practically unchanged over a wide range of temperature.

The residue left after the extraction of starch from lentil may be used as cattle feed ; it contains (air-dry basis): moisture, 8.32 ; protein, 38.95 ; starch, 21.99, crude fibre, 26.75 ; and ash, 4.26% (Qureshi, *Pakist. J. sci. Res.*, 1949, **1**, 63).

Feed—Lentil husk and bran are used as feed for livestock, especially dairy cows. Analysis of husk gave the following values (dry basis): protein, 11.1 ; fat, 0.7 ; carbohydrate, 47.5 ; fibre, 25.6 ; ash, 3.1 ; and digestible protein, 1.3% ; nutritive ratio, 40. Lentil bran contains (dry basis): protein, 20.5 ; fat, 3.2 ; carbohydrate, 71.7 ; calcium (CaO), 0.43 ; phosphorus (P_2O_5), 0.79 ; digestible protein, 12.7 ; and total digestible nutrients, 55.0%. Feeding trials with bullocks have shown that lentil bran mixed with wheat straw maintains positive balances in respect of nitrogen, calcium and phosphorus. It is comparable to brans of Bengal gram and *arhar* in nutritive value and superior to wheat bran (Linton *et al., J. agric. Sci.*, 1934, **24**, 260 ; Woodman, *Bull. Minist. Agric., Lond.*, No. 124, 1945, 17 ; Sinha & Sahai, *Proc. Indian Sci. Congr.*, 1956, pt III, 359).

Leaves and stalks, fresh or dried as hay, are used as cattle feed. Analysis of lentil hay gave the following values: moisture, 10.23 ; fat, 1.80 ; protein, 4.37 ; carbohydrate, 50.03 ; fibre, 21.36 ; mineral matter (sol.), 10.82 ; and mineral matter (insol.), 1.39% (Thorpe, VII, 275 ; Sen, *Bull. agric. Res. Inst. Pusa*, No. 70, 1917, 36).

Green manure—Lentil is sometimes cultivated for green manure. The crop survives winter snow in Kashmir and makes rapid growth in spring before the land is puddled for rice. Sown at the rate of 32-40 lb. per acre in October, two to three weeks after the harvest of paddy, it gave 3,900 lb. of green matter when cut in the following April (Chavan & Patil, *Poona agric. Coll. Mag.*, 1952–53, **43**, 70 ; Fotidar, *Indian Fmg*, 1949, **10**, 111).

Production & Trade

Production—On an average 1.6–1.9 million acres are devoted annually to cultivation of lentil in India, producing 219–338 thousand tons of the pulse. Major areas of production are in Madhya Pradesh, Bihar, Uttar Pradesh and West Bengal. In Madhya Pradesh, districts of Saugor, Jabalpur, Bilaspur, Hoshangabad and Chhindwara account for nearly 73% of the total area in that State. Similarly in Bihar, the districts of Patna, Champaran, Gaya and Shahabad contain about 75% of the total area. In Uttar Pradesh, the important districts are Bahraich, Deoria, Gonda, Banda and Bareilly. In West Bengal, the districts of Murshidabad, Malda and 24-Parganas account for about 74% of the area. The yield per acre is high in West Bengal and Bihar, while it is smaller in Uttar Pradesh and Madhya Pradesh (*Marketing of Pulses in India*, 1958, 7, 9, 11, 98–99, 106–107, 109, 175–177).

Marketing—About 41.0% of total production is retained in the various States by the producers for seed and edible purposes and nearly 59.0% is available for marketing to other regions. The cultivators dispose of the crop mainly as whole seed. Some of the important assembling centres in the various States are: Patna, Buxar, Gaya and Sultanganj in Bihar ; Saugor, Bhatapara and Piparia in Madhya Pradesh ; Chitbargaon, Allahabad and Dehra Dun in Uttar Pradesh ; Jiaganj and Howrah in West Bengal (*Marketing of Pulses in India*, 1958, 20, 49, 132).

Lentil is sold often after processing into *dhal*, whole or split: whole pulse without husk is called variously as *Malka masur*, *Chanti* or *Gota* and is valued more than split *dhal*. The processing is done by crushing the seeds 2 or 3 times in hand or power driven chukkies and separating the *dhal*, *chooni* and husk, after each crushing. The percentage of recovery in lentil ranges from 65–80% as *dhal* (whole or split) and 11–25% as *chooni* (broken bits) and husk (*Marketing of Pulses in India*, 1958, 33, 64).

Price—Based on size of seeds, lentil is classified in trade as bold, medium and small. Generally bold quality fetches a premium over medium and small qualities. In some places besides size, the place of origin also matters. In Calcutta, bold lentil from Saugor, Jabalpur and Bhopal fetches a higher premium over small and medium ones from Bihar and U.P. The main criterion in determining the size is the weight of 1,000 grains. Small grains weigh up to 21.0 g., medium 21–31 g. and bold 31.1 g. and above The Civil Supply Department in U.P., the Food Department in Madhya Pradesh and Army Service

TABLE 5—AVERAGE WHOLESALE PRICES (PER MAUND) OF LENTIL IN SOME IMPORTANT MARKETS (1955-57)*

	1955 Rs.	1956 Rs.	1957 Rs.
Calcutta	11.06	17.26	17.60
Kanpur	n.a.	16.79	17.37
Patna	13.18	21.15	22.31
Gwalior	8.61	15.91	16.38

* *Marketing of Pulses in India*, 1958, 182.
n.a. not available.

Crops have prescribed specifications for lentil, whole as well as split, based on limits of refraction due to presence of dirt and damaged grains and also on moisture content. Table 5 summarizes the average wholesale prices in some of the important markets during the years 1955–57 (*Marketing of Pulses in India*, 1958, 35, 36, 38, 149, 152, 153).

Lentil — *see* **Lens**

LEONOTIS R.Br. (*Labiatae*)

A genus of herbs and shrubs distributed chiefly in Africa. One species extends into tropical Asia and America and seems to have naturalized in India.

L. nepetaefolia R.Br.

D.E.P., IV, 625; Fl. Br. Ind., IV, 691; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 185; Kirt. & Basu, Pl. 777.

HINDI & BENG.—*Hejurchei;* MAR.—*Dipmal;* GUJ.—*Matijer, matisul;* TEL.—*Ranabheri.*

MUNDARI—*Agia janum;* SANTAL—*Dare dhompo, janum dhompo.*

An ornamental herb or shrub, 1.2–1.8 m. high, cultivated or found naturalized almost throughout the hotter parts of India, but nowhere common. Stem stout, puberulous; leaves large, 6.3–15 cm. × 3.8–10 cm., long-petioled, ovate, crenate-serrate, membranous; flowers in verticillasters, orange-scarlet, bristly; nutlets oblong-obovoid, c. 4 mm. long, obliquely truncate, margins ribbed.

Analysis of seeds gave the following values: moisture, 8.8; ether extr. (fatty oil), 28.0; protein, 23.6; crude fibre, 14.3; N-free extr., 19.3; and ash, 5.9%. Glucose, fructose, and a phytin-like substance containing inositol, phosphorus and calcium have been identified. Steam-distillation of seeds yields 2% of a volatile oil. The fatty oil extracted from the seeds is similar to olive oil and has the following characteristics: sp. gr.$^{25°}_{25°}$, 0.8984; $n^{20°}$, 1.4673; iod. val. (Hanus), 82.5; sap. val., 191.2; acid val., 11.2; R.M. val., 0.29; Polenske val., 0.15; acet. val., 4.87; and unsapon. matter, 3.09%. The component fatty acids of the oil are: linoleic, 11.9; oleic, 64.6; myristic, 1.3; palmitic, 12.0; and stearic, 1.2% (*Chem. Abstr.*, 1949, **43**, 3491; 1946, **40**, 747).

The leaves yield a bitter principle, fatty oil (1%), a resin, resinic acid, and ash (7%); calyx and flowers contain similar substances. Traces of an alkaloid-like compound are present in various parts of the plant; the seeds possess feeble anti-malarial activity (Wehmer, II, 1079; *Chem. Abstr.*, 1949, **43**, 3491).

FIG. 26. LEONOTIS NEPETAEFOLIA—FLOWERING BRANCH

The plant is reported to be used in skin affections. Ashes of flowers are applied to scalds and burns. In Madagascar, the plant is considered depurative, emmenagogue, febrifuge, laxative and narcotic and used in skin diseases, amenorrhoea and fevers. A decoction of leaves is used in Porto Rico as tonic and febrifuge. In Brazil, the leaves are used in the treatment of rheumatic affections (Kirt. & Basu, III, 2024; Dalziel, 461).

L. leonurus R.Br., a native of South Africa, is grown in Indian gardens for ornament. The plant is reported to possess medicinal properties. The leaves contain two phenolic compounds ($C_9H_{10}O_5$, m.p. 247–48° and $C_8H_{10}O_5$, m.p. 229.5–30°), a resin (19.8%) and a reddish oil with a high boiling point. The plant is mildly anthelmintic but too weak to be of practical value. It is also feebly narcotic. A decoction of leaves is used as purgative and as an emmenagogue in

Africa ; it is also used for coughs and colds (Watt & Breyer-Brandwijk, 156–57).

LEONURUS Linn. (*Labiatae*)

A small genus of herbs distributed in Europe and parts of Asia, Africa and America. Two species are found in India.

L. cardiaca Linn. COMMON MOTHERWORT

Fl. Br. Ind., IV, 678 ; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 192 ; Blatter, II, Pl. 54, Fig. 1.

A perennial pubescent herb, up to 1.2 m. in height, occurring in the Himalayas from Kashmir to Kumaon at altitudes of 1,800–3,000 m. Rootstock stout ; lower leaves ovate-cordate or ovate-lanceolate, deeply and irregularly lobed, upper leaves lanceolate, lobed or entire ; flowers pink or white ; nutlets smooth.

Dried leaves and flowering tops of the plant are medicinal. They are considered tonic, antispasmodic, diuretic, analgesic and emmenagogue, and prescribed to women suffering from hysteria, heart palpitation, amenorrhoea and general weakness after fever. The drug tones up generative organs and uterine membrane, allays nervous irritability and affords relief from pain in stomach and gall bladder. It may be administered in the form of tincture, infusion or decoction. The leaves cause dermatitis (Auster & Schaefer, Lieferung 14, No. 41, 1958 ; Youngken, 733 ; Steinmetz, II, 270 ; Wren, 237 ; Chopra, 1958, 559).

The dried plant contains alkaloids (0.35%), saponins, tannins (2.14%), bitter principles, essential oil (0.05%), carbohydrates (2.8%), and traces of vitamins A and C. Stachydrine has been identified in the alkaloidal fraction (Auster & Schaefer, loc. cit. ; *Chem. Abstr.*, 1947, **41**, 7677).

L. sibiricus Linn. SIBERIAN MOTHERWORT

D.E.P., IV, 625 ; Fl. Br. Ind., IV, 678 ; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 193 ; Kirt. & Basu, Pl. 771B.

HINDI—*Guma*.

An annual herb, up to 2 m. in height, found in Assam, Bengal and Bihar, extending southwards to Mysore. Leaves long petioled, pinnati- or palmatipartite ; flowers red, pink or blue ; nutlets smooth.

The plant is not indigenous to India but found as a weed throughout the plains. In China, all parts of the plant, especially the seeds are used in medicine. The dried herb is credited with tonic, alterative, vulnerary and emmenagogic properties. It is employed in puerperal and menstrual disorders. The leaf extract has been found to be effective towards uterus contraction. Leaves and roots are used as febrifuge (Burkill, II, 1329 ; Kirt. & Basu, III, 2014 ; Monachino, *Econ. Bot.*, 1956, **10**, 42).

FIG. 27. LEONURUS SIBIRICUS—FLOWERING BRANCH

The plant contains an alkaloid, leonurine ($C_{13}H_{19}O_4N_1$, m.p. 238° ; yield, 0.05%), fatty oil (0.5%), a resin (0.37%) and resinic acid (0.83%). Lauric, oleic, linoleic, and linolenic acids have been isolated from the leaves. The alkaloid has a curare-like effect on motor endings. It produces a marked diuresis when intravenously injected into rabbit ; in concentrations up to 1 : 1,000 it possesses haemolytic action. Administered to cats in small doses it acts as a respiratory stimulant ; in large doses it causes respiratory paralysis (Wehmer, II, 1038 ; *Chem. Abstr.*, 1931, **25**, 771, 1285 ; Hilditch, 1956, 154).

Analysis of seeds gave the following values: moisture, 5.38 ; protein, 10.06 ; fatty oil, 37.02 ; carbohydrates, 38.12 ; fibre, 1.89 ; and ash, 7.52%. The fatty oil (sp. gr.$^{15.5°}$, 0.9199 ; $n^{15.5°}$, 1.4739 ; iod. val., 112.47)

consists of 84.85% unsaturated glycerides. The seeds contain an alkaloid, leonurinine ($C_{10}H_{14}O_2N_2$, m.p. 262–63°), and a volatile oil (Quisumbing, 819; *Chem. Abstr.*, 1933, **27**, 3287; 1935, **29**, 2659).

LEOPARDS (Class *Mammalia*, order *Carnivora*, sub-order *Aeluroidea*, family *Felidae*)

D.E.P., VI (4), 51; Fn. Br. Ind., Mammalia, **1**, 1939, 222, 239, 247, 323; Sterndale, 82.

Included under this title are the leopard or panther, the snow leopard (Ounce), the clouded leopard and the hunting leopard (Cheetah). The leopard and the ounce belong to the genus *Panthera*; the clouded leopard and the hunting leopard fall under the genera *Neofelis* and *Acinonyx* respectively.

The leopard, *Panthera pardus* Linn. (Hindi—*Cheeta*; Beng. & Mar.—*Cheeta bagh*; Tel. & Mal.—*Chinna puli*; Tam.—*Chiruthai*; Kan.—*Honiga, kerkal;* Kashmir–*Suh;* Manipur—*Kajengla;* Naga—*Hurrea, kon*; Lepcha—*Syik*), is distributed throughout Asia and Africa, except the Sahara. It is much smaller than the lion or the tiger. The thickness and texture of the coat and the markings on various parts of the body are not uniform. The ground colour varies from greyish or whitish buff to olivaceous with a buffish tinge; the underside and under surfaces of limbs are generally white. The black spots on the head are prominent and sometimes extend for a short distance behind. The outer sides of limbs and belly are heavily spotted; elsewhere the pattern consists of rosettes varying considerably in size and spacing.

The leopard prefers scrub jungle or rocky places with bushes and caves for shelter. In its natural surroundings it is not readily recognized because of the obliterative effect of the colour pattern. The leopard preys upon any animal it can overpower but, like the tiger, if incapacitated by injury or old age, it may become a man-eater and also prove a menace to live-stock in villages round about its hiding places. In strength, the leopard, in proportion to its size, is nearly equal to the tiger; it is more active and lithe in movements and more dangerous because of its ability to climb up trees.

Photo: Maharaja of Baroda

FIG. 28. LEOPARD—PANTHERA PARDUS FUSCA

The leopard is known to breed all the year round, the period of gestation is 13 weeks and usually two or four cubs are born in a litter. The breeding interval in the wild state is not known with certainty; in captivity, however, the interval between litters is about a year.

There are three races of the leopard, viz. *Panthera pardus fusca* Meyer, *P. pardus pernigra* Gray and *P. pardus millardi* Pocock. The race *fusca* or common Indian leopard has a bright ground colour and is found in almost all forests in India. The race *pernigra* occurs from Sikkim to Nepal at 1,800–2,400 m., and probably also in Kumaon and Garhwal. In winter it descends to the lower altitudes. It differs from race *fusca* in having a coarser, thicker and more woolly winter coat with large rosettes standing out boldly against a comparatively pale ground colour; a good many leopards of this race are black. The race *millardi* is found in Kashmir, apparently at high altitudes. It differs from other races by the absence of bright hue in the pelage and by the possession of small close set rosettes (Pocock, *J. Bombay nat. Hist. Soc.*, 1930–31, **34,** 307; Mosse, ibid., 1930–31, **34,** 350, 673, 1015; Phythian-Adams, ibid., 1948–49, **48,** 461; Ellerman & Morrison-Scott, 316).

Leopards are hunted for their skins which are highly prized. The body fat is used in external applications for muscular pains and sprains. The fat extracted from the abdomen of *Panthera pardus fusca* is pale cream in colour and has the following characteristics: sap. val., 196.4; iod. val., 62.4; and free fatty acids (as oleic), 3.2%. The fatty acid composition of the fat is as follows: myristic, 2.3; palmitic, 20.1; stearic, 13.7; arachidic, 1.7; unsaturated C_{14}, 1.8; unsaturated C_{16}, 10.8; oleic, 39.2; octadecadienoic, 2.1; and unsaturated C_{20}, 8.3%: the component glycerides are: dipalmito-olein, 8.3; palmitostearo-olein, 10.9; dioleopalmitin, 20.9; dioleostearin, 18.5; mono-oleohexadecenostearin, 17.9; mono-oleohexadecenopalmitin, 21.7; and hexadecenodiolein, 1.8 (mol. %) (Pathak & Trivedi, *Biochem. J.*, 1958, **70,** 103).

Snow leopard or Ounce, *Panthera* (*Uncia*) *uncia* Schreber (SIMLA & KUMAON—*Bharal-haye*; KUNAWAR—*Thurbagh*; KASHMIR—*Thurwagh*; BHOTIA—*Ikar*,

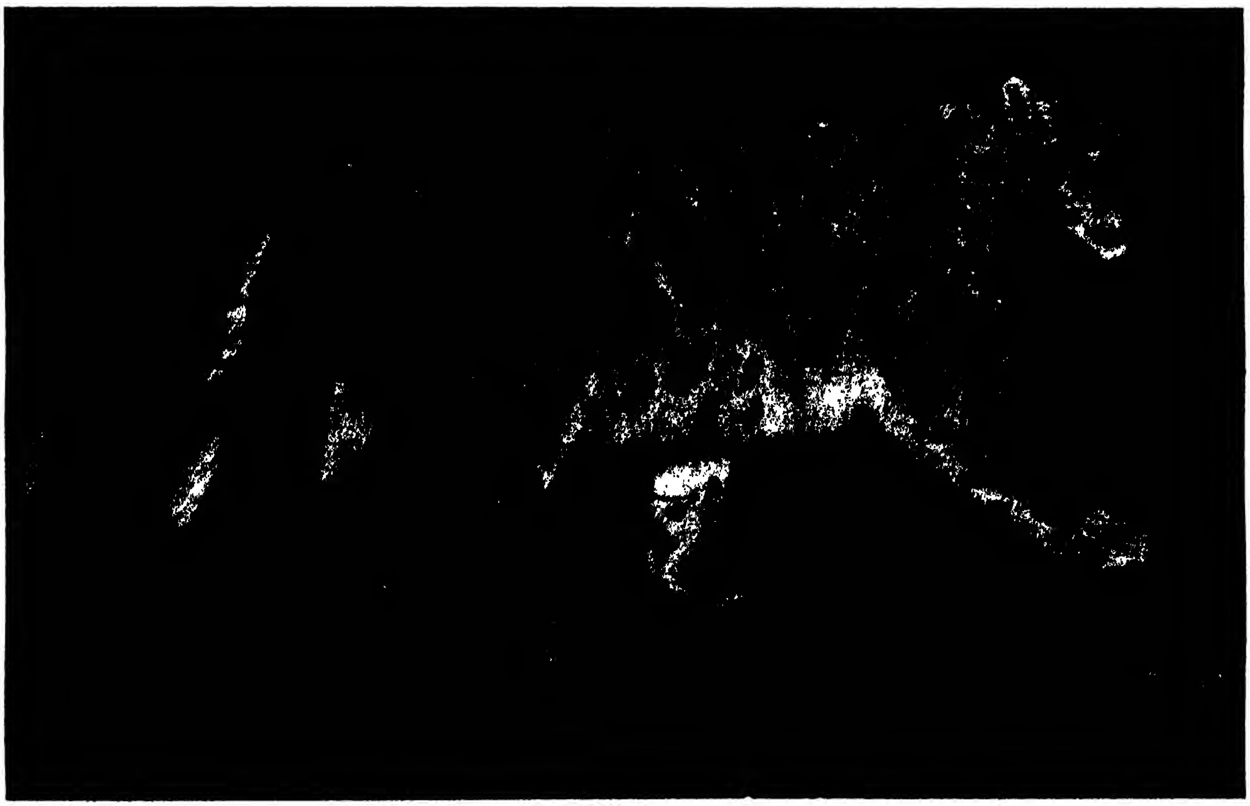


Photo: E. P. Walker, New York Zoological Society

FIG. 29. SNOW LEOPARD—PANTHERA (UNCIA) UNCIA

sachak), is found in the Himalayas, from Kashmir to Sikkim, at altitudes of 3,500–4,000 m.; it descends to lower altitudes during winter. The ground coat is soft grey, sometimes tinged with buff, paling to white on the underside. The spots are unbroken and distinct on the head, nape and lower parts of limbs. The animal is valued for its fur and is trapped in pits.

Clouded leopard, *Neofelis nebulosa macrosceloides* Hodgson (NEPAL—*Lamchitia*; BHOTIA—*Kung*; LEPCHA—*Pungmar, satchuk*), is found in the forests of Nepal, Sikkim, Bhutan and Assam. It differs from other felines in having exceptionally long canine teeth. It is rarely seen as it is nocturnal in habit and inhabits dense evergreen forests. The ground colour of the coat varies from grey or earthy brown to pale or rich yellowish brown fading to white or pale tawny on the underside. The clouded pattern of markings on the flanks is made up of dark blotches separated by paler interspaces. Though wary and savage in its natural surroundings, it can be tamed.

The hunting leopard or cheetah is different from other felines in not having sheaths on claws. Two races are distinguished, viz. the Indian and the African. The Indian race, *Acinonyx jubatus venaticus* Griffith, as compared to the typical African, has a thinner, less woolly winter coat; the male has no mane. The ground colour of the body varies from tawny to pale buff, the underside being white. A feature of the markings is a conspicuous black stripe from the eye to the mouth on each side; the rest of the body is marked by closely set solid spots. The cheetah loves open country and being an easy target has been hunted out almost to its extinction in India. It runs at great speed (up to 72 km. per hour) and has been occasionally tamed and trained for hunting (Pocock, *J. Bombay nat. Hist. Soc.*, 1930-31, **34**, 330; Prater, 44–45, 55; Ellerman & Morrison-Scott, 314–15, 320–21).

Leopard Lily—*see* **Belamcanda**

LEPIDAGATHIS Willd. (*Acanthaceae*)

A large genus of perennial herbs, undershrubs or shrubs, distributed throughout the tropics. About 25 species occur in India.

L. cristata Willd.

D.E.P., IV, 625; Fl. Br. Ind., IV, 516; Kirt. & Basu, Pl. 723.

MAR.—*Bhuiterada*; TAM.—*Karappan poondu.*

A stiff undershrub with numerous branches procumbent from a hard perennial rootstock found in dry situations and rocks in Delhi, Rajasthan, Gujarat, Cutch, Konkan, Deccan, N. Circars and Carnatic. Leaves sessile, opposite, linear-oblong, 2–4 cm. × 0.3–1 cm.; flowers white or pale pink dotted with brown or purple spots, in sub-radical clusters; capsules small, ovoid, subacute with two ovoid-oblong, rounded seeds.

The leaves of the plant are used as fodder. Analysis of leaves gave the following values (dry basis): protein, 9.25; fat (ether extr.), 3.90; carbohydrates, 40.85; fibre, 32.56; ash, 13.44; iron (Fe_2O_3), 1.32; calcium (CaO), 1.97; phosphorus (P_2O_5), 0.31; and silica, 6.24% (Lander, *Misc. Bull. Indian Coun. agric. Res.*, No. 16, 1942, 84).

The plant is used as a bitter tonic in fevers. It is also applied to itchy affections of the skin (Kirt. & Basu, III, 1894).

L. hamiltoniana Wall. ex Nees (MUNDARI—*Agnikhair, ote agia janum*) is a dwarf herb with woody rootstock, linear or narrowly oblong leaves and purple flowers found in dry situations in the upper Gangetic plain, Bihar, Chota Nagpur, Orissa and N. Circars. The Oraons and Mundas are reported to use the plant as an application for skin diseases (Bressers, 113; Kirt. & Basu, III, 1895).

L. incurva D. Don syn. *L. hyalina* Nees is a small perennial herb, found throughout northern India from Jammu to upper Assam ascending to 1,500 m. and in Andhra, Madras, Kanara and Konkan. Leaves of the plant are chewed to relieve cough. *L. trinervis* Wall. ex Nees (GUJ.—*Harancharo, paniru*) is a small herb found in North-West Himalayas and Sikkim and from Bihar to central, western and S. India. The plant is considered a bitter tonic (Burkill, II, 1330; Kirt. & Basu, III, 1895).

LEPIDIUM Linn. (*Cruciferae*)

A large cosmopolitan genus of annual or perennial herbs, undershrubs or shrubs. Five species occur in India of which *L. sativum* is widely cultivated as a salad plant.

L. draba Linn. = *Cardaria draba* (Linn.) Desv.

D.E.P., IV, 626; III, 415; Fl. Br. Ind., I, 160.

A perennial herb, 30–90 cm. high, found as a weed of cultivation in Punjab and extending westwards. Leaves oblong to oblong-lanceolate, repand-toothed; flowers white, in branched panicles; pods deltoid with rounded angles.

The plant is used as a vegetable and as fodder for cattle, horses, goats and camels in Afghanistan

and Baluchistan. Tender leaves are cyanogenetic. The plant is poisonous to fish ; in Australia, it is suspected to poison stock. The plant is reported to possess anti-scorbutic properties (Burkill, 1909, 8 ; Wehmer, I, 393 ; Chopra, 1958, 587 : Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 43 ; Kirt. & Basu, I, 175).

The seeds have a sharp bitter taste and yield a sulphur-containing volatile oil. A light brown, semi-drying, fixed oil with the following characteristics is obtained by solvent extraction in 9.2–10.8% yield: sp. gr.$^{15^\circ}_{15^\circ}$, 0.9129 ; $n_D^{25^\circ}$, 1.4750 ; acid val., 2.05 ; sap. val., 180.9 ; iod. val. (Hanus), 136.1 ; R.M. val., 1.22 : Polenske val., 0.39 : and unsapon. matter, 2.4% (Wehmer, I, 393 ; Eckey, 445–46).

L. latifolium Linn.

D.E.P., IV, 627 ; Fl. Br. Ind., I, 160.

Ladakh—*Gonyuch*.

An erect, perennial, leafy herb, 0.6–1.2 m. high, found from Kashmir westwards. Leaves oblong-lanceolate, entire or dentate: radical leaves petioled, cauline leaves sessile ; flowers minute, white, in densely panicled bracteate corymbs ; pods small, ovoid.

The plant contains resins, two alkaloids, flavone compounds, a saponin and a sulphur-containing volatile oil. It is considered depurative and anti-scorbutic, and used as a resolvent in skin affections : an infusion of the plant is given for liver and kidney diseases. Pharmacological tests show that the plant infusion increases the amplitude and decreases the frequency of the isolated frog heart and regulates the rhythm : it depresses, temporarily, the blood pressure in a dog (*Chem. Abstr.*, 1954, **48**, 11727 : Gildemeister & Hoffmann, II, 513 ; Kirt. & Basu, I, 176).

The plant is said to be browsed by sheep and goats. Seeds contain a mustard oil glucoside and myrosin (*Chem. Abstr.*, 1945, **39**, 4432 : Wehmer, I, 394).

L. sativum Linn. Garden Cress

D.E.P., IV, 627 ; Fl. Br. Ind., I, 159 ; Kirt. & Basu, Pl. 67.

Hindi—*Halim, hurf* ; Beng.—*Halim, aleveri* ; Mar.—*Ahliva* ; Guj.—*Asalio, halim* ; Tel.—*Adalavitulu, adeli, adityalu* ; Tam.—*Aliverai* ; Kan.—*Allibija, kurutige*.

Punjab—*Halim, shargundei, tezak* ; Mundari—*Chanchur*.

A small, herbaceous, glabrous annual, 15–45 cm. high, cultivated as a salad plant throughout India ; it is found as an escape. Leaves variable, entire or variously lobed or pinnatisect: radical leaves long-petioled, twice pinnatisect, cauline leaves sessile, linear, linear-oblong or pinnatifid ; flowers small, white, in long racemes ; pods small, orbicular-ovate, notched at apex, winged ; seeds solitary in each cell.

L. sativum is a polymorphous species, considered to have originated primarily in the highland region of Ethiopia and Eritrea ; Europe and western Asia are regarded as secondary centres of form origination (Stchenkova, *Bull. appl. Bot. Pl.-Breed., Ser.* IX, No. 1, 1932, 183).

Garden cress thrives on any good light soil, but does best on moist loam. It can be grown at all elevations, all the year round, but the best crop is obtained in the winter season. Seeds are sown in the plains from September to February and on the hills, from March to September. They are sown thick and covered until germination begins. In a few days after sowing, the plants are ready for cutting. To get a continuous supply of leaves, sowing is done in succession at intervals of 8 days (Gollan, 36–37 : Choudhri, 118–19 ; Firminger, 166 ; Williams & Williams, 205).

When grown for garnish, seeds are sown in open situations in shallow drills 8–12 in. apart. After-culture consists in weeding and irrigation once a week during the dry weather. The crop is ready for harvest in 4–6 weeks. For seed production, a few plants are left in the ground until the seeds are fully mature. The plants are then pulled out, dried, and seeds separated by threshing (Gollan, 37 ; Choudhri, 119 ; Firminger, 166 ; Bailey, 1947, I, 890).

Garden cress leaves are consumed raw in salads ; they are also cooked with vegetable curries and used as garnish. The plant is used as fodder for horses, camels, etc. It is also medicinal and used in the treatment of asthma, coughs and bleeding piles. Leaves are mildly stimulant and diuretic, and useful in scorbutic diseases and liver complaints. The root is used in secondary syphilis and tenesmus. The seeds of the plant are rubefacient, galactagogue, emmenagogue, laxative, tonic, aphrodisiac and diuretic. They are used in poultices for hurts and sprains (Kirt. & Basu, I, 174 ; Fl. Assam, I, 71 : Nadkarni, I, 736 ; Caius, *J. Bombay nat. Hist. Soc.*, 1938–39, **40**, 706 ; Parsa, *Qualit. Plant. Mat. Veg.*, 1960, **7**, 73).

Analysis of leaves gave the following values: water, 82.3 ; protein, 5.8 ; fat, 1.0 ; carbohydrate, 8.7 ; mineral matter, 2.2 ; calcium, 0.36 ; and phosphorus, 0.11% ; *trace elements :* iron (28.6 mg./100 g.), nickel (40 μg./kg.), cobalt (12 μg./kg.) and

iodine (110 μg./kg.); *vitamins:* vitamin A, 2,970 i.u.; thiamine, 0.11; riboflavin, 0.17; niacin, 1.0; and ascorbic acid, 87 mg./100 g. Cooked leaves contain: vitamin A, 3,300 i.u.; thiamine, 70 μg.; riboflavin, 0.15 mg.; niacin, 0.8 mg.; and ascorbic acid, 39 mg./100 g. (*Hlth Bull.*, No. 23, 1951, 32; Watt & Merrill, *Agric. Handb. U.S. Dep. Agric.*, No. 8, 1950, 25; Wehmer, I, 393; Iodine Content of Foods, 75).

The plant yields on steam-distillation 0.115% of a colourless volatile oil (Cress Oil) with a characteristic pungent odour, containing variable proportions of benzyl isothiocyanate and benzyl cyanide. The former is a hydrolytic product of the glucoside glucotropaeolin and is released by the action of myrosin, which is normally present in the plant, when the comminuted material is subjected to steam-distillation; benzyl cyanide is formed by the action of hot steam on the plant material and is the predominant constituent of the volatile oil when steam-distillation is effected with prior comminution of the material. The volatile products of crushed leaves show antibacterial activity against *Bacillus subtilis* and *Micrococcus pyogenes* var. *aureus;* their activity against *Escherichia coli* is less pronounced (Gildemeister & Hoffmann, II, 511–13; Allen, IV, 512; *Chem. Abstr.*, 1953, **47,** 12503).

Analysis of cress seeds gave the following values: moisture, 5.69; protein, 23.5; fat, 15.91; ash, 5.7; phosphorus (P_2O_5), 1.65; calcium, 0.31; and sulphur, 0.9%. The seeds contain an alkaloid (0.19%), glucotropaeolin, sinapin (choline ester of sinapic acid), sinapic acid (4-hydroxy-3 : 5-dimethoxycinnamic acid, $C_{11}H_{12}O_5$, m.p. 192°), mucilaginous matter (5%), and uric acid (0.108 g./kg.). On steam-distillation, they yield a volatile oil similar to that from the whole herb. The oil has pronounced oestrogen activity; tests on immature rats receiving 3–4 drops of the oil with their diet showed consistently better development and higher weights of the ovaries than control animals and exhibited several haemorrhagic follicles in the ovaries (Sahasrabuddhe & De, *Curr. Sci.*, 1943, **12,** 23; Gildemeister & Hoffmann, II, 512–13; Wehmer, suppl., 118; *Chem. Abstr.*, 1953, **47,** 4048).

The seeds yield up to 25.5% of a yellowish brown, semi-drying oil with a peculiar disagreeable odour, used for burning and soap making. The oil has the following characteristics: sp. gr.$^{33°}$, 0.909; $n^{31°}$, 1.4695; acid val., 0.96; sap. val., 185.0; iod. val. (Wijs), 131.4; acet. val., 5.8; R.M. val., 1.14; Polenske val., 0.69; Hehner val., 93.8; and unsapon. matter, 1.8%. The percentages of saturated and unsaturated acids in the oil are as follows: palmitic, 1.27; stearic, 6.01; arachidic, 1.54; behenic, 1.73; lignoceric, 0.2; oleic, 61.25; and linolenic, 28.0. The unsaponifiable matter contains β-sitosterol and α-tocopherol (1830 μg./g. oil). The oil possesses anti-oxidant properties; the optimum stabilising concentration when used as an additive for linseed oil is 10% (Vasudev *et al.*, *J. sci. industr. Res.*, 1956, **15B,** 725; Allen, II, 182; Lotfy *et al.*, *J. Amer. Oil Chem. Soc.*, 1957, **34,** 96).

The seed mucilage, known as Cress Seed Mucilage, is used as a substitute for tragacanth and gum-arabic. It allays the irritation of the mucous membrane of intestines in dysentery and diarrhoea. The mucilage consists of a mixture of cellulose (18.3%) and uronic acid-containing polysaccharides; acid hydrolysis yields L-arabinose, D-galactose, L-rhamnose, D-galacturonic acid and D-glucose. Aqueous extracts of seeds flocculated clay suspensions; the activity is greatly enhanced by the addition of a little alum solution (Whistler & Smart, 333; *Chem. Abstr.*, 1953, **47,** 5974).

L. iberis Linn. is found in southern Europe and extends to Siberia. The seeds of this herb are medicinal and are reported to be imported into Bombay from Persia and sold in bazaars under the name *Towdri* for use as blood purifier; they are prescribed in bronchitis and dropsy. When soaked in water they become thickly coated with mucilage. The plant is rubefacient in rheumatism. Flowering tops and seeds contain an amorphous bitter principle, lepidin. The plant yields a sulphur-containing volatile oil (Dymock, Warden & Hooper, I, 119; Wehmer, I, 394).

The seeds of the white variety of this species, *L. iberis* var. *alba* (Hindi—*Safed towdri*) contain a fatty oil, mucilage, colouring matter, and a volatile oil. Extraction with petroleum ether gave 5.5% of a yellow fatty oil with a mustard oil-like odour; it has the following characteristics: sp. gr.$^{25°}$, 0.9408; $n^{25°}$, 1.4109; acid val., 20.3; sap. val., 182.3; iod. val. (Hanus), 115.8; and unsapon. matter, 0.74%. The fatty acids of the oil are: oleic, 12.9; linoleic, 47.87; linolenic, 5.43; erucic, 31.97; stearic, 0.54; and palmitic, 1.22%; the unsaponifiable matter contains phytosterol and sitosterol. The seed mucilage contains 19–20% cellulose and on hydrolysis gives galactose, arabinose, rhamnose and galacturonic acid (Joshi & Tewari, *Arch. Pharm.*, *Berl.*, 1957, **290,** 215, 257).

L. ruderale Linn. is an annual, erect or diffuse herb found in Bhutan, Kumaon and Kashmir at altitudes of 2,100–3,900 m. The herb and ground seeds yield volatile oils similar to that of other *Lepidium* spp. Aqueous extracts of the herb cause a brief drop in blood pressure and depress respiration in mice and rabbits. The plant is used in impetigo (Wehmer, I, 393; *Chem. Abstr.*, 1954, **48,** 4122; Kirt. & Basu, I, 176).

Lepidolite — *see* **Lithium Ores; Mica**

LEPIONURUS Blume (*Opiliaceae*)

Fl. Br. Ind., I, 583; Fl. Assam, I, 250.

A very small genus of shrubs or small trees, occurring in tropical Asia. One species is recorded in India.

L. sylvestris Blume syn. *L. oblongifolius* Mast. (Lushai—*Anpangthuam*; Mikir—*Impai-kelok*) is a shrub or small tree, 2 m. high, with oblong-lanceolate to elliptic or obovate leaves and minute greenish flowers found in Sikkim, northern Bengal, Assam, Khasi, Lushai, Aka and Abor hills, at altitudes of 600–1,500 m. The plant and its roots are reported to be used as a poultice for headache in children (Burkill, II, 1331).

LEPIRONIA Rich. (*Cyperaceae*)

Fl. Br. Ind., VI, 684.

A small genus of herbs distributed from Madagascar through tropical Asia to Australia and Polynesia. *L. articulata* Domin syn. *L. mucronata* Rich. is reported to be found near Tranquebar in Madras State, perhaps only cultivated or as a casual escape.

L. articulata is a sedge with tufted stems, *c.* 0.9 m. high. It is cultivated in Borneo by transplanting clumps in ponds, *c.* 0.3 m. deep, containing black mould at the bottom. The crop is harvested after a year when it is full grown. Stems are cut and dried in the sun on layers of wood ashes, freed from leaf sheaths and tied into bundles. They are used for making mats (Fl. Madras, 1674; Burkill, II, 1332).

LEPISANTHES Blume (*Sapindaceae*)

A genus of shrubs and trees distributed in tropical Asia. About six species occur in India.

L. tetraphylla (Vahl) Radlk. syn. *Hemigyrosa canescens* Thw.

D.E.P., IV, 221; Fl. Br. Ind., I, 671; Benthall, 120, Fig.

Mar.—*Kurpa*; Tel.—*Korivi*; Tam.—*Nekota, karadipongan, masamathi*; Kan.—*Kurpah, mooltaga, kalu-yette*; Oriya—*Panikusum*.

A shrub or a moderate-sized evergreen tree with rounded crown and more or less crooked trunk, occurring in many parts of the Deccan Peninsula up to an altitude of 900 m. It has been planted as a roadside tree in Calcutta. Bark smooth, brownish, exfoliating in large flakes; leaves paripinnate: leaflets 2–4 pairs; flowers small, whitish, polygamo-monoecious, in panicles; fruits yellow, tomentose, 1–2.5 cm. in diam., sub-globose or trigonous, enclosing 2–5 seeds set in a white translucent pulp.

The fruit has a sweetish pulp and is edible. The wood (wt., 60 lb./cu. ft.) is white, moderately soft and even-grained; it is occasionally used for house building (Benthall, 120; Gamble, 192).

LEPTADENIA R. Br. (*Asclepiadaceae*)

A small genus of erect or twining shrubs distributed in tropical and sub-tropical parts of Asia and Africa. Two species are found in India.

L. pyrotechnica (Forsk.) Decne. syn. *L. spartium* Wight

D.E.P., IV, 630; Fl. Br. Ind., IV, 64.

Guj.—*Khip*.

Punjab—*Kip*; Rajasthan—*Khimp*.

A much-branched, often leafless shrub up to 1.8 m. high, found chiefly in dry and sandy places in Punjab, western U.P., Rajasthan and northern parts of Bombay along the sea coast. Leaves linear or linear-lanceolate, 2.5–5.6 cm. long, glabrous; flowers yellow, in small umbellate cymes; follicles lanceolate, terete, 8.7–11.2 cm. long.

The plant yields a fibre used for rope making. It is reported to be suitable also for paper manufacture. The plant provides fodder for cattle, horses and camels. It is also used for thatching purposes. The tuberous root is consumed as vegetable (Dalziel, 388; Nadkarni, I, 738).

L. reticulata Wight & Arn.

D.E.P., IV, 630; Fl. Br. Ind., IV, 63.

Sans.—*Meda*; Hindi—*Dori*; Mar. & Guj.—*Dodi, nahanidodi, khirkhodi, raidodi, shinguti*; Tel.—*Kalasa, mukkutummudu, palatige*; Tam.—*Palaikkodi*.

A much-branched twining shrub found in sub-Himalayan tracts of Punjab and U.P. and throughout the Deccan Peninsula up to an altitude of 900 m., particularly in hedges. Bark yellowish brown, corky, deeply cracked; leaves ovate-cordate, coriaceous,

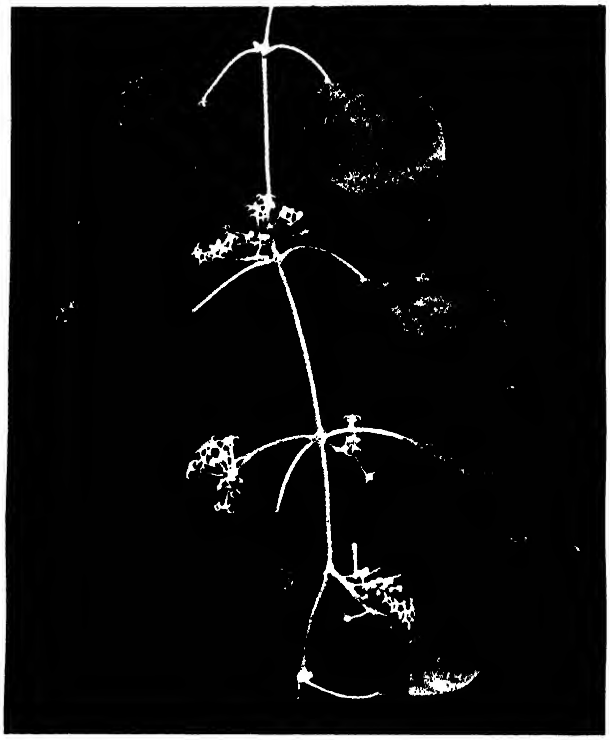


FIG. 30. LEPTADENIA RETICULATA—FLOWERING BRANCH

glabrous above, more or less finely pubescent beneath; flowers in many-flowered cymes, greenish yellow; follicles sub-woody, 6.3–9 cm. long, turgid.

The plant is stimulant and restorative. It is occasionally used in nose and ear troubles; leaves and roots are useful in skin affections and wounds. Alcoholic (50%) extracts of roots and leaves show antibacterial activity against Gram-positive and Gram-negative bacteria, including *Micrococcus pyogenes* var. *aureus*, -var. *albus*, and -var. *citreus*, *Bacillus megatherium*, *Escherichia coli*, *Salmonella typhi*, and *Proteus vulgaris*; they are also active against *Trycophyton rubrum*. Intravenous administration of aqueous extract of stems has a pronounced and prolonged hypotensive action in anaesthetized dogs; it appears to be nontoxic. The plant has been clinically tested and found useful in the treatment of habitual abortion in women (Kirt. & Basu, III, 1630; Nadkarni, I, 596; Patel & Dantwala, *Indian J. Pharm.*, 1958, **20,** 241; Agarwal *et al.*, *Indian J. med. Res.*, 1960, **48,** 457; Mangeshikar, *Antiseptic*, 1958, **55,** 487).

The stems and roots of the plant yield a waxy material composed mainly of aliphatic esters derived from long-chain alcohols (C_{24}–C_{34}) and long-chain acids (C_{28}–C_{32}); a colourless crystalline substance (m.p. 115°) is also present, but not characterized. A considerable amount of sterols is present in the free condition; stigmasterol is the major component and small quantities of sitosterols, of which γ-sitosterol has been identified, are also present. A fructosan (7–8 hexose units) of the inulin type has been separated from the tubers. Tubers, shoots and follicles of the plant are eaten as vegetable in times of scarcity (Murti & Seshadri, *Proc. Indian Acad. Sci.*, 1944, **20A,** 266; Mukherjee & Srivastava, *J. sci. industr. Res.*, 1951, **10B,** 324).

LEPTOCHLOA Beauv. (*Gramineae*)

A genus of annual grasses, found in the tropical and sub-tropical regions of both hemispheres. About 5 species occur in India.

L. chinensis Nees*

D.E.P., IV, 630; III, 423; Fl. Br. Ind., VII, 299; Blatter & McCann, 244.

Hindi—*Chanhel*; Tel.—*Cheepura gaddi*; Tam.—*Aeri pul*; Kan.—*Kadu sanna karisajjai hullu.*

An annual grass with erect stem, 0.6–1.2 m. high, arising from a geniculate base, found throughout India in moist places, along borders of water courses and in paddy fields. It grows luxuriantly under favourable conditions and affords good fodder for cattle. Analysis of grass (from Indonesia) gave the following values (dry basis): protein, 9.57; fat, 1.48; carbohydrates, 43.49; fibre, 31.65; and ash, 13.80%. The grain is reported to be used as famine food in East Africa (Burkill, II, 1333; Ranga Achariyar, 292; Fl. Assam, V, 112; Jacob, *Madras agric. J.*, 1940, **28,** 63; Walandouw, *J. sci. Res. Indonesia*, 1952, **1,** 208).

L. obtusiflora Hochst.

Fl. Br. Ind., VII, 299.

An erect annual grass with branched leafy stem, 60 cm. tall, found in S. India at elevations of 300–600 m. It does not thrive under dry conditions. Analysis of grass (from Madras) gave the following values: moisture, 6.88; crude protein, 3.99; carbohydrates, 43.87; ether extr., 1.19; crude fibre, 36.51; ash, 7.56; lime (CaO), 0.523; phosphoric acid (P_2O_5), 0.793; and insolubles, 4.36%. It is not toxic to cattle though it contains small amounts (0.011% at full bloom and 0.0082% after seeding) of hydrocyanic

* This species and *L. panicea* (Retz.) Ohwi are regarded by some authors as varieties of the same species. However, they are distinguishable in the field by appearance and their chromosome numbers are also different, 2n=40 in *L. chinensis* and 2n=20 in *L. panicea* (Haines, V, 972); Fl. Assam, V, 112; Darlington & Wylie, 429; Bor, personal communication).

FIG. 31. LEPTOCHLOA PANICEA—FLOWERING BRANCH

acid (*Mem. Dep. Agric. Madras,* No. 36, 1954, 611 ; Chandrasekhara Iyer *et al., Madras agric. J.,* 1948, **35,** 379).

L. panicea (Retz.) Ohwi syn. *L. filiformis* Fl. Br. Ind. non Beauv. ; *L. contracta* Blatter & McCann

Fl. Br. Ind., VII, 298.

An annual grass with erect slender stems, 30–60 cm. high, found in moist situations near canals and ponds throughout India up to about 600 m. It is eaten by cattle when young. Analysis of grass (from Indonesia) gave the following values (dry basis): protein, 6.73 ; fat, 0.87 ; carbohydrates, 43.39 ; fibre, 30.84 ; and ash, 18.17% (Rhind, 33 ; Walandouw, *J. sci. Res. Indonesia,* 1952, **1,** 208).

L. neesii (Thw.) Benth. syn. *L. polystachya* Benth., an annual grass found sometimes in marshes in the eastern districts of Andhra Pradesh and Madras, is readily eaten by cattle when young (Burkill II, 1333).

LEPTONYCHIA Turcz. (*Sterculiaceae*)

Fl. Br. Ind., I, 378.

A small genus of shrubs or trees distributed in tropical Asia and Africa. Two species are found in India.

L. heteroclita Kurz syn. *L. glabra* Turcz. is an evergreen shrub or a small tree reported to be found in South Andamans. Leaves oblong-lanceolate, 5–10 cm. long, base somewhat oblique, glabrous or thinly stellate-hairy ; flowers in axillary cymes, small, whitish ; capsule depressed pyriform, *c.* 1.25 cm. long, coriaceous, rugose, with one black seed. In Malaya, leaves of the plant are reported to be used in poultices for ulcers ; a decoction of the roots may be taken before child birth and as febrifuge. *L. moacurroides* Bedd. is a closely related tree, *c.* 9 m. in height, found in South India up to an altitude of 900 m. (Burkill, II, 1334 ; Bourdillon, 50).

LEPTORHABDOS Schrenk (*Scrophulariaceae*)

D.E.P., IV, 631 ; Fl. Br. Ind., IV, 303 ; Blatter, II, Pl. 47, Fig. 4.

A small genus of annual herbs found in Central Asia and N. India. *L. parviflora* Benth. (syn. *L. benthamiana* Walp. ; *L. linifolia* Walp.) is a small herb with pinnatisect leaves and many flowered slender racemes, found in temperate western Himalayas, from Kumaon and Garhwal to Kashmir at altitudes of 1,500–3,300 m., and further westwards in Baluchistan, Afghanistan and Persia. It is reported to be one of the principal summer fodders for sheep and goats throughout the juniper forests of Baluchistan (Pennell, 93–94).

Lepus — *see* **Rats and other Rodents**

LESPEDEZA Michx. (*Leguminosae*)

A fairly large genus of herbs, undershrubs or shrubs, occurring in temperate and tropical regions throughout the world. About 15 species are recorded in India.

L. cuneata G. Don syn. *L. sericea* Miq. non Benth.
PERENNIAL LESPEDEZA

Fl. Br. Ind., II, 142 ; Fl. Japan, 417, Fig. 1251.

DEHRA DUN—*Khunju.*

An erect undershrub, 60–90 cm. high, with tough long branches found along the Himalayas from Hazara and Kashmir to Bengal up to 2,400 m. and in Nilgiris and Palnis up to 2,100 m. Leaves trifoliolate, ascending, crowded: leaflets 6–12 mm. long, linear-cuneate, rigidly coriaceous, usually glabrous

I.A.R.I., New Delhi

FIG. 32. LESPEDEZA CUNEATA—FLOWERING BRANCH

above and silky hairy below ; flowers 2–4, pale yellow or white, tinged with purple, borne on short pedicels : pods very small, orbicular.

Perennial lespedeza is grown in U.S.A. for forage purposes and for soil improvement. Efforts have been made in India to raise crops from seeds obtained from U.S.A. ; the results have not proved encouraging in many parts of the country except in Assam and in the experimental farm of the Indian Agricultural Research Institute, New Delhi. The growth of the plant is slow in winter ; with the advent of frost the shoots dry up, but sprout again as the season warms up. The growth is profuse during the rainy season and four cuttings can be taken between May and September [Whyte *et al.*, 284 ; McKee, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1852, 1946 ; Woodford, *Indian Fmg*, 1940, **1**, 274 ; Yegna Narayan Aiyer, 1950, 122 ; Pal & Singh, *Indian Fmg*, 1949, **10**, 423 ; *Indian Fmg*, 1951, **12**(1 & 2), 31].

L. cuneata contains tannin (whole plant, 5.1–8.0% ; leaves, 7.5–18%) and the plant is not much relished by stock. The tannin content is particularly large if the plant is not cut early ; for making hay, the plant is cut when it is 25–37.5 cm. high ; a yield of 1–4 tons of hay per acre per season has been recorded. Feeding trials have shown that the hay is inferior to *L. striata* hay in nutritive value. The crop can be converted into silage. Analysis of cuttings from plants at the Indian Agricultural Research Institute showed that they contain 23.18% protein but the outturn is not much and the feed material becomes fibrous unless cut early [McKee, loc. cit. ; Morrison, 324 ; Shuey, *Chemurg. Dig.*, 1949, **8**(6), 25 ; *Indian Fmg*, 1951, **12**(1 & 2), 31].

The stalks, left after harvesting the crop can be used as raw material for paper pulp. The pulp obtained (yield, *c.* 50%) by semi-chemical and chemical treatments is short-fibred, has high gloss and is easy to bleach. It is suitable for cheap paper. Bleached pulp can be blended with long-fibred pulps and used for speciality papers [Sproull & Banks, *Chemurg. Dig.*, 1949, **8**(12), 7].

The seeds of the plant are eaten by wild birds. They yield a semi-drying oil (iod. val., 153.8) (Wiley *et al.*, *J. Amer. Oil Chem. Soc.*, 1951, **28**, 459).

L. striata Hook. & Arn. = *Microlespedeza striata* Makino ; *Kummerowia striata* Schindl. JAPANESE CLOVER, ANNUAL LESPEDEZA, COMMON LESPEDEZA

D.E.P., IV, 631 ; Bailey, 1947, II, 1845 ; Fl. Japan, 415, Fig. 1245.

A pubescent, tufted, decumbent or ascending annual, 45 cm. or more in height, distributed in Japan, Korea, Manchuria, Mongolia and China. It has become naturalized in Upper Shillong (Assam) and is found growing wild in many places. The plant bears numerous small trifoliate leaves and pink or purple flowers (Hector, II, 695 ; Woodford, *Indian Fmg*, 1940, **1**, 274 ; Hutcheson *et al.*, 303).

L. striata is commonly grown in U.S.A. as pasture and fodder crop and for erosion control. It is said to be acid tolerant and suitable for poor and worn out lands. It is particularly valuable for permanent pastures since it reseeds itself ; it is often grown mixed with grasses or sweet clover, but for hay it is sown pure. A yield of 1–3 tons of hay per acre is reported [Hutcheson *et al.*, 305 ; Ahlgren, 124, 129 ; Morrison, 322 ; Henson & Hanson, *Fmrs' Bull. U.S. Dep. Agric.*, No. 2113, 1958].

Common lespedeza hay is comparable to alfalfa hay in feeding value ; it is a rich source of carotene. Mouldy hay is, however, liable to produce a haemorrhagic disease, similar to that produced by sweet clover (*Melilotus* spp.) (Morrison, 323–24, 1105).

The plant is also used as green manure. The seeds are eaten by wild birds; they yield a semi-drying oil (iod. val., 149.7) (McKee, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1852, 1946; Davison, *Leafl. U.S. Dep. Agric.*, No. 373, 1954; Wiley *et al.*, *J. Amer. Oil Chem. Soc.*, 1951, **28,** 459).

L. stipulacea Maxim. = *Kummerowia stipulacea* Makino (KOREAN LESPEDEZA) is an annual grown in U.S.A. for fodder purposes. It has been introduced in India and considered valuable for grazing and hay. It is useful also as a green manure crop and for erosion control (Pal & Singh, loc. cit.; Whyte *et al.*, 362-63; Hutcheson *et al.*, 305; Morrison, 323).

LETTSOMIA Roxb. (*Convolvulaceae*)

A genus of climbing shrubs distributed in tropical continental Asia and Malaysia. About 20 species occur in India. This genus is now regarded as a synonym of *Argyreia* Lour. by most authors.

L. elliptica Wight = *Argyreia elliptica* (Wight) Choisy
SILVERWEED

D.E.P., IV, 632; Fl. Br. Ind., IV, 192; Talbot, II, Fig. 429.

MAR.—*Bondvel, sonariel, khedari*; TAM.—*Unnayangodi*; KAN.—*Uganihambu.*

A large handsome climbing shrub, found in Deccan, Carnatic, Anaimalai hills and western ghats from Konkan southwards to Kerala up to 1,200 m.

FIG. 33. LETTSOMIA ELLIPTICA—FLOWERING BRANCH

Leaves ovate or elliptic-lanceolate; flowers rose coloured or pale purple, in lax corymbose or paniculate cymes; fruits small, depressed-globose, orange coloured.

Fresh leaves and twigs of the plant are employed as green manure in paddy fields in some parts of Mysore. Analysis of green material gave the following values: N, 0.63; P_2O_5, 0.14; K_2O, 0.47; and CaO, 0.80% (Iyengar, *Mysore agric. J.*, 1956, **31,** 5).

L. aggregata Roxb. = *Argyreia aggregata* (Roxb.) Choisy syn. *L. mysorensis* C.B. Clarke (MAR.—*Bondvel*; TEL.—*Errakuta*; KAN.—*Uganiballi, buden-bally*) is a large climbing shrub with ovate-cordate leaves and small, campanulate, pink flowers, in dense capitate cymes found in Chota Nagpur, Orissa (Puri), Deccan, Carnatic, Anaimalai hills and western ghats from Konkan southwards to Kerala.

A paste of the leaves is applied externally in cough and quinsy. The stem is used for tying bundles (Kirt. & Basu, III, 1709; Rama Rao, 276).

L. setosa Roxb. = *Argyreia setosa* (Roxb.) Choisy (MAR.—*Bhaisvel*; TEL.—*Mayatige, verribodditige*; TAM.—*Unnayangodi*; ORIYA—*Bono-monda, noibhada*; MADHYA PRADESH—*Bhaisela, budhwara*) is a large climber with ovate-cordate leaves and pretty rose coloured or whitish flowers in dense corymbs occurring in Bihar, Chota Nagpur, Orissa, upper Gangetic plain, Madhya Pradesh, Mt. Abu, N. Circars, Deccan, eastern slopes of Palni hills and Konkan southwards to Kerala. The leaves are eaten as vegetable. The pliable stems are used as rope for tying bundles (Witt, 164; Firminger, 437).

Lettuce—*see* **Lactuca**

LEUCAENA Benth. (*Leguminosae*)

A genus of trees and shrubs native of tropical America and Pacific Islands. *L. glauca* Benth. is widely cultivated in tropical and sub-tropical countries and is naturalized in India.

L. glauca Benth. WHITE POPINAC, LEAD TREE

D.E.P., IV, 632; Fl. Br. Ind., II, 290.

GUJ.—*Lasobaval, vilayatibaral*; TEL.—*Kaniti*; TAM.—*Tagarai, nattuccavundal*; MAL.—*Takaranniram*; ORIYA—*Rajokasundiri.*

LAKHIMPUR—*Toira kadam*; GUNTUR—*Nagarikesari.*

A large shrub or a small tree, up to 9 m. in height, found throughout the plains of India. Bark brownish; leaves bipinnate, 7.5–18 cm. long: pinnae 4–8

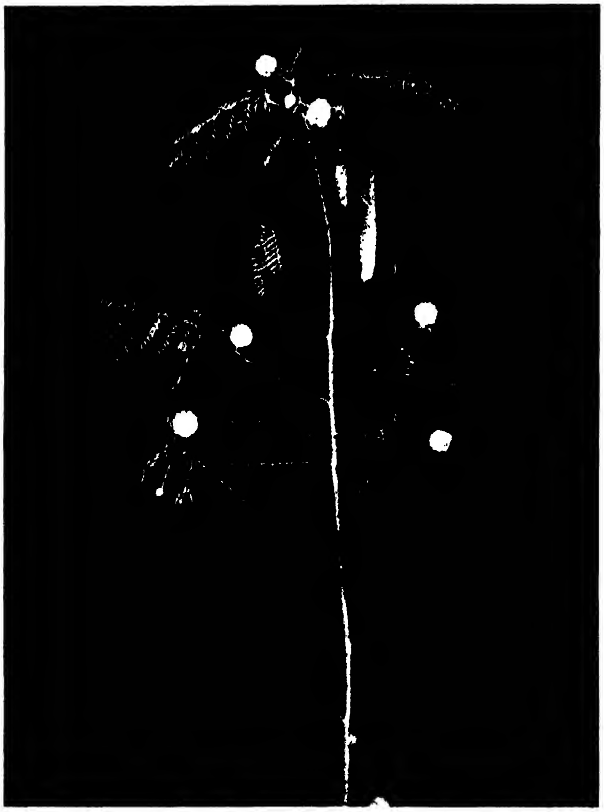


FIG. 34. LEUCAENA GLAUCA—FLOWERING AND FRUITING BRANCH

pairs, 5-9 cm. long, leaflets 10–15 pairs, linear-oblong, c. 10 mm. × 3 mm.; flowers small, whitish; pods straight, flat, 12.5-15 cm. × 1.3–2 cm., obliquely triangular at apex, narrowed at base; seeds 15–25, dark brown, with hard shining testa.

L. glauca is mostly grown in hedges of gardens and near villages. It prefers deep clayey soil and is drought-resistant over long periods. Its rugged habit, deep root system, abundant seeding and quick growth enable it to establish itself even in rather unfavourable situations. It regenerates and spreads readily from self-sown seeds, but natural viability of seeds is low (c. 10%). For cultivation purposes, the seeds are scarified before sowing; steeping in hot water at 70°–80° for five minutes also facilitates germination. In starting fresh plantations, it is usual in the Philippines to inoculate the soil with nodule organisms (by mixing soil from old plantations of *L. glauca*) before planting. *L. glauca* can be propagated from cuttings (2–5 cm. diam.) and stumps. It coppices vigorously and the growth of coppice shoots is more rapid than that of seedling plants (Use of Leguminous Plants, 163, 218–19; Venkataratnam, *Madras agric. J.*, 1948, **35,** 179; Parker, *Indian For.*, 1929, **55,** 641; Troup, II, 486).

The utility of *L. glauca* for afforesting grasslands has been proved in the Philippines. It is also planted for filling forest gaps, as wind-break and for checking soil erosion. It is grown in many countries as shade and cover plant in plantations of tea, coffee, cocoa, rubber, cinchona, teak and sal; in Guntur (South India), it is planted in betel vine gardens. It sheds its leaves regularly and enriches top soil with organic matter. It stands pruning and even stumping; under normal conditions, 1,000 fully grown trees, when pruned and topped every two months, yield c. 15,000 kg. of fresh leaves per acre per annum. The leaves contain (dry basis): N, 3.85; P_2O_5, 0.38; K_2O, 1.76; and CaO, 4.10%. Leaves and twigs are rich in nitrogen and potassium salts and can be used after composting. Powdered seeds also make useful manure (Troup, II, 486; Burkill, II, 1337; Dijkman, *Econ. Bot.*, 1950, **4,** 337; Whyte *et al.*, 285; Krishnaswamy, *Indian For.*, 1956, **82,** 153; Reddi, *Madras agric. J.*, 1946–48, **34–35,** 155; Idnani & Chibber, *Sci. & Cult.*, 1952-53, **18,** 362).

Tops, leaves, pods and seeds of the plant are relished by cattle, sheep and goats. Analysis of green foliage gave the following values: dry matter, 29.4; protein, 5.3; fat, 0.6; N-free extr., 12.2; fibre, 9.7; mineral matter, 1.8; digestible protein, 3.9; and total digestible nutrients, 17.5%; nutritive ratio, 3.5. The leaves are a good source of protein and carotene and can be employed as supplement to alfalfa leaf meal in poultry rations. Seeds may be used as concentrates for dairy animals (Whyte *et al.*, 285; Neal, 360; Morrison, 327, 1026; Ylagan & Sanchez, *Philipp. Agric.*, 1957–58, **41,** 238).

When consumed in excessive quantities, all parts of *L. glauca* are toxic to monogastric animals, like horses, pigs, rabbits and chickens, and cause great loss of hair; regeneration of hair is observed when the animals stop eating the plant. *L. glauca* is also reported to cause loss of fertility. The toxicity is due to an alkaloid, leucenine or leucenol, β-[N-(3-hydroxy-4-pyridone)]-α-amino-propionic acid, $C_8H_{10}O_4N_2$, m.p. 226–27°, reported to be identical with mimosine (from *Mimosa pudica* Linn.). Addition of small amounts of soluble iron salts to the feed counteracts the toxic effects to a considerable degree. Heat treatment of leaves and seeds after moistening lowers the alkaloid content. It has been recently reported that *L. glauca* has the property of extracting selenium from the soil and concentrating it in the

seeds. Many of the toxic symptoms observed in animals feeding on the plant are similar to those of selenium poisoning (Neal, 360; Whyte *et al.*, 285; Walandouw, *J. sci. Res. Indonesia*, 1952, **1**, 204; Heilbron & Bunbury, III, 175; Merck Index, 571; Manske & Holmes, I, 209–11; *Chem. Abstr.*, 1952, **46**, 1664; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 88).

The seeds yield (8.8%) a dark green fatty oil with the following characteristics: sp. gr.$^{28°}$, 0.9165; $n^{28°}$, 1.4674; sap. val., 185; iod. val. (Hanus), 110; free acids (as oleic), 3%; and unsapon. matter (containing β-sitosterol), 4.7%; the fatty acid composition of the oil is as follows: palmitic, 12.74; stearic, 5.01; behenic, 3.64; lignoceric, 0.67; oleic, 23.63; and linoleic, 54.31%. The seeds also contain mucilage, composed of mannans, galactans and xylans. Stachyose is reported to be present in the seeds (Farooq & Siddiqui, *J. Amer. Oil Chem. Soc.*, 1954, **31**, 8; *Chem. Abstr.*, 1942, **36**, 1140; 1945, **39**, 1735).

The wood of *L. glauca* (wt., *c.* 23 lb./cu.ft.) is hard, strong, medium-textured and close-grained. As it is available only in small sizes, it has little value as timber. It is burned as fuel or for making charcoal (calorific value: *wood*, 3,895 cal./g.; *charcoal*, 7,250 cal./g.). The wood has been tried as a raw material for paper pulp; a short-fibred pulp (mean fibre length, 1.18 mm.) is obtained by the semi-chemical process in 70.6–81.8% yield; it may be employed for paper manufacture especially in combination with long-fibred pulps, e.g. bamboo pulp (Record & Hess, 286; Brown, 1941, II, 132; Dijkman, loc. cit.; *Biol. Abstr.*, 1957, **31**, 2,382).

The bark of the plant is used in the Philippines for toughening fishing tackles. Attempts have also been made to utilize the bark (tannin content, 16.3%) for tanning purposes, but the extract is dark in colour and produces a leather of unsatisfactory appearance. The leaves of the plant contain tannin (3%) and quercitrin (0.08%) (Burkill, II, 1337; Record & Hess, 285; *Chem. Abstr.*, 1948, **42**, 8505; 1949, **43**, 8617; Teik, *Sci. Ser. Dep. Agric., Malaya*, No. 24, 1951, 16).

Young shoots and immature pods are eaten as vegetable in some countries. Dry seeds are eaten after parching. The stem bark is taken in Assam to relieve internal pains. The plant is reported to be a worm repellent and is also a fish poison. The shiny seeds are used in fancy baskets, purses and ornaments [Burkill, II, 1336–37; Use of Leguminous Plants, 219; Kirt. & Basu, II, 914; *J. sci. Res. Indonesia*, 1952, **1** (suppl.), 22; Webb, loc. cit.; Benthall, 208].

LEUCAS R. Br. (*Labiatae*)

A large genus of herbs or undershrubs distributed throughout the tropical regions of the Old World; one species is found in tropical America and West Indies. About 35 species occur in India.

L. aspera Spreng.

D.E.P., IV, 632; III, 317; Fl. Br. Ind., IV, 690; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 166; Kirt. & Basu, Pl. 775.

Hindi & Beng.—*Chota halkusa*; Tel.—*Tummachettu, tummi*; Tam.—*Thumbai*; Kan.—*Thumbe gida*; Mal.—*Thumba*; Oriya—*Bhutamari*.

Bombay—*Tamba*; Deccan—*Thurduribaji*; Delhi—*Gopha*; Mundari—*Goma ara*.

A herbaceous, much-branched, erect or diffuse annual, 30–60 cm. high, found more or less throughout India as a weed in cultivated fields, waste lands and road sides. Leaves subsessile, linear or narrowly oblong-lanceolate, entire or crenate; flowers small, white, in dense terminal or axillary whorls; nutlets small, oblong, smooth, brown.

The plant is fragrant and used as a pot-herb. It is eaten in times of scarcity. It is commonly used as an antipyretic in villages in S. India. The juice of the leaves is used as an external application for psoriasis, chronic skin eruptions and painful swellings. In North Bengal, flowers are given with honey for coughs and colds in children. An alcoholic extract of leaves shows anti-bacterial activity against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli* (Shirazi, *Indian J. Pharm.*, 1947, **9**, 116; Kirt. & Basu, III, 2020; George *et al.*, *J. sci. industr. Res.*, 1947, **6B**, 42).

The plant contains an alkaloid and a glucoside; the latter on hydrolysis gives an optically active substance which stops the isolated frog's heart in diastole (Shirazi, loc. cit.).

L. cephalotes Spreng.

D.E.P., IV, 633; III, 318; VI(1), 577; C.P., 483; Fl. Br. Ind., IV, 689; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 168; Kirt. & Basu, Pl. 773.

Hindi—*Dhurpi sag, deldona, goma*; Beng.—*Barahalkusa*; Mar.—*Deokhumba, shetvad, tumba*; Guj.—*Kubo, kubi*; Tel.—*Peddatummi*.

Punjab—*Chatra, guldoda, phuman, sisalius*; Delhi—*Gubbha*; Mundari—*Gomanaki ara*.

An erect, scaberulous or pubescent, stout annual, 30–100 cm. high, found as a common weed in cultivated grounds and waste lands throughout the greater part of India, ascending up to 1,800 m. in the Himalayas. Leaves shortly petioled, narrowly ovate or ovate-lanceolate, crenate-serrate; flowers small, white, in dense terminal globose whorls; nutlets small, smooth, brown.

The plant is pungent to taste. It is used as pot-herb. The seeds yield an oil used for illumination purposes; they are used as an auxiliary in the extraction of dye from *Rubia sikkimensis* Kurz. The plant is reported to possess rennet-like properties. It is considered stimulant, diaphoretic, laxative, anthelmintic, antiseptic and insecticidal. A syrup of the flowers is used as a domestic remedy for coughs and colds (Kirt. & Basu, III, 2018; Chopra, 1958, 512, 597).

L. lavandulaefolia Rees syn. *L. linifolia* Spreng.

D.E.P., IV, 633; Fl. Br. Ind., IV, 690; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 167; Kirt. & Basu, Pl. 776.

HINDI—*Guma, halkusa, kumbha*; BENG.—*Halkasa*; MAR.—*Kuva*; GUJ.—*Jhinanpannikubo*; TEL.—*Pulatumni*; MAL.—*Thumba*; ORIYA—*Gaisa*.

BIHAR—*Gumar, dulphi*; MUNDARI—*Guma ara*.

A herbaceous, erect, slender annual, 30–60 cm. high, found as a weed in fields, pastures and waste lands throughout the country. Leaves opposite, linear-lanceolate, entire or sparingly serrate; flowers white, in axillary and terminal whorls; nutlets small, oblong, pale brown, dull.

The plant has a strong flavour and is reported to be used as a seasoning in Indonesia. Leaves are eaten as pot-herb. The plant is eaten by cattle when fodder is scarce. Flowers are offered in temples. A decoction of leaves or crushed leaves is used as a sedative in nervous disorders; it is used also as vermifuge and stomachic. A poultice of fresh leaves is applied to old sores and wounds. Crushed leaves are used externally for dermatosis. Roots, stems and leaves are cyanogenetic (Burkill, II, 1338; Bressers, 119; Van Steenis-Kruseman, *Bull. Org. sci. Res. Indonesia*, No. 18, 1953, 25; Quisumbing, 821, 1046).

L. martinicensis R. Br.

Fl. Br. Ind., IV, 688; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 169.

MUNDARI—*Guma ara, huring sengel sui*.

A tall, stout annual herb, 0.6–1.2 m. high, found in Bihar, Chota Nagpur, Deccan and S. India. Leaves opposite, ovate, oblong or lanceolate, obtuse, coarsely crenate-serrate; flowers small, white, in axillary globose whorls; nutlets obovoid-oblong, dark brown, shining.

The plant has a mint-like odour; the leaves are eaten. It possesses insecticidal properties and is burnt in rooms for expelling mosquitoes in West Africa. An infusion of the plant is given for gastro-intestinal troubles and colds [Dalziel, 461; Bressers, 119; Irvine, *Colon. Pl. Anim. Prod.*, 1955, **5**(1), 34].

L. zeylanica R. Br.

D.E.P., IV, 634; Fl. Br. Ind., IV, 689; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 171; Kirt. & Basu, Pl. 774.

A herbaceous, erect, pubescent or hispidly hairy annual, 15–50 cm. high, found as a weed in waste lands and river beds in Assam, Saurashtra, Deccan and S. India at altitudes of 900–2,100 m. Leaves opposite, ovate-lanceolate or lanceolate, entire or sparingly serrate; flowers white, in terminal whorls; nutlets small, obovoid-oblong, dark-brown or black, shining.

The leaves of the plant are sometimes eaten in Ceylon; they are also used as flavouring. A volatile oil is obtained by the steam-distillation of the whole plant (Macmillan, 302; Burkill, II, 1338; Dymock, Warden & Hooper, III, 124–25).

The plant is reported to be used for fevers and skin diseases in Indonesia. A decoction of leaves is used as a lotion for ulcers of the nose [*J. sci. Res. Indonesia*, 1952, **1** (suppl.), 29; Burkill, II, 1338–39].

L. clarkei Hook. f. (MUNDARI—*Merom guchu ara*) is a slender annual found as a common weed of cultivation in Bihar and Chota Nagpur. The leaves of the plant are eaten as pot-herb (Bressers, 119).

L. lanata Benth. is an erect perennial herb found in western Himalayas from Kashmir to Kumaon, at altitudes of 900–2,400 m.; it is also found in upper Gangetic plain, Nepal, Chota Nagpur, Darjeeling (North Bengal), Assam, Deccan, Konkan, and S. India. Tender shoots of the plant are used as vegetable. They are also given for cough after frying (Fl. Assam, III, 526).

L. mollissima Wall. is a slender herb found in subtropical Himalayas, upper Gangetic plain, Bihar, Chota Nagpur, Orissa, West Bengal, Aka and Khasi hills, Madhya Pradesh, Deccan, Konkan and Kanara. The leaves are eaten as pot-herb by the Santals.

L. stelligera Wall. syn. *L. eriostoma* var. *longifolia* Hook. f. (MAR.—*Barumbi*; GUJ.—*Dungaraukubo*) is an erect herb found in Saurashtra, Deccan,

Konkan, western ghats, hills of S. Kanara and Mysore up to 900 m. The plant is considered stimulant, carminative and emmenagogue (Kirt. & Basu, III, 2023).

L. urticaefolia R. Br. (Guj.—*Kobo* ; Tam.—*Perunthumbai* ; Delhi—*Goma, gumma*) is an erect herbaceous annual found from Bihar westwards to Baluchistan, Madhya Pradesh, Rajasthan, Saurashtra, Gujarat, Deccan and S. India. The plant is used as fodder for camels and goats (Burkill, 1909, 61).

LEUCOJUM Linn. (*Amaryllidaceae*)

Bailey, 1947, II, 1848.

A small genus of ornamental bulbous plants distributed in Europe and the Mediterranean region. One species is grown in Indian gardens.

L. aestivum Linn. is a native of central and southern Europe, grown in Coonoor and Ootacamund where it flowers freely. It is a hardy plant up to 30 cm. in height ; bulbs large, ovoid, 2.5–3.7 cm. in diam. : leaves linear, strap-shaped, yellowish green ; flowers white tipped with green. The plant thrives in open, rich, moist soils and is propagated by bulbs (Firminger, 328 ; Chittenden, III, 1156).

The bulbs are edible after cooking. They contain a sinistrin-like carbohydrate and two alkaloids, leucojin and leucojitin (?), and are considered emetic (Wehmer, I, 165).

Levant Berries — *see* **Anamirta**

LEYCESTERIA Wall. (*Caprifoliaceae*)

Fl. Br. Ind., III, 16.

A small genus of shrubs distributed from Himalayas to China. Five species occur in India.

L. formosa Wall. (Jaunsar—*Bhujnali* ; Kumaon—*Malkarr, duni, saunjla* ; Garhwal—*Danda bhekar* ; Lepcha—*Tunguk*) is a deciduous shrub, 1–2 m. in height, found almost throughout the temperate Himalayas at altitudes of 1,500–3,000 m. and in Khasi hills from 1,500 to 1,800 m. Stem hollow with smooth bark : leaves ovate-lanceolate : flowers purplish : berry sub-globose, red. The hollow stems of the shrub are made into whistles and flutes in Jaunsar (Gamble, 398).

Leycesteria spp., especially *L. formosa* Wall., are grown for ornament in some parts of Europe and America. They are conspicuous in bloom on account of their handsome purplish bracts. Propagation is by seed or by cuttings (Bailey, 1947, II, 1852).

Lice — *see* **Insects and Insect Pests**

LICHENS

D.E.P., IV, 635 ; Smith, A. L., 1921, 464 pp.

Sans.—*Sailaja, saileya* ; Hindi—*Charila, pathar-ka-phul* ; Tel.—*Rathipoovvu* ; Tam.—*Marappasi.*

Punjab—*Chalchalira, charcharila, ausneh, hiunsew* ; Bombay—*Mota dagada phul, barik dagada phul.*

Lichens constitute a class of small perennial plants, which are unique in that they are actually combinations of two organisms—a fungus and an alga—growing together in symbiotic association. The fungal element lives upon the food elaborated by the algae, while the algal element gets its moisture and mineral nutrients from the fungus ; the fungus also protects the alga against desiccation and injury.

Lichens are widely distributed from the arctic to the tropics and are found on soil, barren rocks and tree trunks. They are not usually found in the neighbourhood of large cities as they are sensitive to smoke and various gases.

The vegetative body of the lichen, called thallus, is composed of fungal mycelia which form a network enclosing algal cells or gonidia. The fungal component is the dominant participant and is usually a member of the *Ascomycetes* ; less frequently and particularly in the tropical species, the fungal component is a *Basidiomycetes*. The algal component may belong to *Myxophyceae* (blue-green algae) or *Chlorophyceae* (bright-green or yellow-green algae). The thalli in some lichen species are thin flat incrustations growing on the substratum ; lichens of this type are called crustose. In foliose lichens, the thallus is flat, leathery, leaf-like and more or less deeply incised, growing in rosettes or irregularly spreading over the substratum. Fruticose lichens have erect or hanging, simple or branched, strap-shaped fronds which may be cylindrical or broadened to thin bands. The thallus may be very minute or large and the colour may be white, green, yellow, red, dark brown or black. The thallus surface may be smooth or rough due to the presence of vegetative outgrowths.

The greater part of the lichen thallus is composed of fungus hyphae woven together into a compact false tissue. In advanced forms, the thallus is differentiated into the upper cortex of compacted hyphae followed by the gonidial layer with algal cells, the medulla or loose hyphal tissue, and the lower cortex, which may be often absent.

Lichens reproduce by means of spores or by soredia. The ascospores or basidiospores of the fungal element are disseminated by wind and germinate in the

presence of moisture into hyphae; each hypha, in its chance encounter with the requisite alga, forms a new lichen. Soredia are minute bits of lichen, composed of one or more algal cells together with a small mass of fungal hyphae, which often get detached from the thallus as a powdery mass and dispersed by wind or water or by insects which feed on lichens; when deposited on suitable substrata, they develop into lichen thalli. Lichens have been produced artificially by growing the component organisms separately in pure cultures and bringing them together.

The classification of lichens is based chiefly on the characters of the fungal element. Two sub-classes are recognized: *Ascolichenes*, in which the fungus is an *Ascomycete* and *Basidiolichenes* (*Hymenolichenes*) in which the fungus is a *Basidiomycete*. The *Ascolichenes* are by far the more important and are subdivided into two series: *Gymnocarpeae* with apothecia and *Pyrenocarpeae* with perithecia. They are further sub-divided into various sub-series and families. The *Basidiolichenes* are few in number and are represented by three closely related genera, *Cora*, *Corella* and *Dictyonema*. They are endemic in tropical and warm countries and are not particularly important from the economic point of view.

Series *Gymnocarpeae* includes most of the lichens of economic value and the families which are important are *Cladoniaceae*, *Gyrophoraceae*, *Lecanoraceae*, *Parmeliaceae*, *Peltigeraceae*, *Roccellaceae* and *Usneaceae*. In India, the genus *Parmelia* and members of the family *Usneaceae* are widely distributed. Series *Pyrenocarpeae* is of little economic value. A species, *Dermatocarpon moulinsii* (family *Dermatocarpaceae*), reported to occur in India finds some minor uses.

Uses — Lichens have been used from the earliest times as animal feeds and also as food for human consumption in times of scarcity; a few are consumed as delicacies. *Cetraria islandica* (Iceland Moss), *Evernia prunastri* (Linn.) Ach. and *Lecanora esculenta* Evers. (Biblical manna) are instances of lichen foods. Species of *Umbilicaria* and *Gyrophora*, called Tripe de roche, have been consumed by arctic explorers. *Gyrophora esculenta* Miyosh. is prized as a food adjunct in China and Japan. Some species of *Parmelia*, *Peltigera*, *Ramalina* and *Usnea* are reported to possess food value. Several lichens are used as fodder for reindeer, cattle, swine and goats, while all but gelatinous lichens are eaten by invertebrates, like caterpillars, snails and mites. Lichens, with few exceptions, are non-poisonous (Llano, *Bot. Rev.*, 1944, **10**, 1; *Econ. Bot.*, 1948, **2**, 15; Lal & Rao, *J. sci. industr. Res.*, 1956, **15C**, 71).

Lichens were once employed for dyeing wool and silk, and colouring materials derived from them were highly valued before the advent of aniline dyes. Certain species of *Roccella* and *Lecanora* yield purple dyes, known in commerce as Orchil or Archil, Cudbear and Litmus. Lichen dyes are still employed in the production of high quality Harris Tweed cloth. Important dye yielding lichens are discussed in detail below. Table 1 includes names of minor dye-yielding lichens recorded from India (Llano, *Bot. Rev.*, 1944, **10**, 1; Hill, 134; Edlin, 135; Leggett, *J.N.Y. bot. Gdn*, 1949, **50**, 107).

Certain lichens containing volatile oil were once used in perfumery and cosmetic industries. *Evernia prunastri*, growing on the stems of oak trees and known as Oak Moss or Mousse de Chene, is highly esteemed by perfumers in Europe for scenting soaps and in compounding many popular scents. The chief odorous principles of oak moss are α- and β-thujone, along with some camphor, borneol and cineol (Llano, *Bot. Rev.*, 1944, **10**, 1; Guenther, VI, 179, 187-91).

Lichens were formerly used as sources of fermentable sugars for the production of ethyl alcohol. *Cetraria islandica* and *Cladonia rangiferina* yield up to 60% polysaccharides readily hydrolysed to glucose. Some species of *Parmelia*, *Evernia* and *Ramalina* yield gums which found application in calico printing and in the production of parchment and cardboard. Many crustaceous lichens contain oxalic acid; *Pertusaria* sp. is reported to be used in France in the manufacture of oxalic acid (Llano, *Bot. Rev.*, 1944, **10**, 1; *Econ. Bot.*, 1956, **10**, 367; Edlin, 135).

Several lichens possess medicinal properties. *Cetraria islandica* is considered useful in chest complaints. Some lichens belonging to *Cladoniaceae*, *Parmeliaceae* and *Usneaceae* elaborate substances which are active against Gram-positive bacteria. The active compounds are dibenzofurans of which usnic acid is the most important. Certain lactonic fatty acids and depsidones related to orcinol also show anti-bacterial activity. Usnic acid is active against *Streptococcus haemolyticus* and *Pneumococcus* spp. and inhibits the growth of tubercle bacillus. Barbatic acid and dibasic roccellic acid, in the form of its half esters or half amides, possess anti-tubercular activity. Atranorin is a fish poison (Asahina & Shibata, 216–23; Bustinza, *Econ. Bot.*, 1952, **6**, 402; Neelakantan & Seshadri, *J. sci. industr. Res.*, 1952, **11A**, 338; Pereira

et al., Indian J. Pharm., 1953, **15,** 287 ; Barry, *Nature, Lond.*, 1946, **158,** 863).

Adverse effects—Lichens have been reported to cause damage to stained window glasses, marble, alabaster and Florentine mosaics, and deface sculptured panels. The presence of a high percentage of lecanoric acid in some *Parmelia* spp. accounts for the disintegration of rocks and monuments. Some lichens have harmful effects on trees and telegraph posts. Lichens sometimes harbour insects harmful to crop plants (*Hort. Abstr.*, 1957, **27,** 621 ; Llano, *Bot. Rev.*, 1944, **10,** 1 ; Seshadri & Subramanian, *Proc. Indian Acad. Sci.*, 1949, **30A,** 15 ; *J. sci. industr. Res.*, 1949, **8B,** 170 ; Neelakantan & Seshadri, ibid., 1952, **11A,** 338).

Chemical composition—Lichen substances are highly complex and their constitutional pattern is distinctive from that of the constituents of higher plants. Lichenin and *iso*lichenin are complex carbohydrates common to the lichen world ; they consist entirely of glucose residues and are intermediate in character between cellulose and starch. Lichenin $[(\alpha)_D^{20^\circ}, +8.3]$ is insoluble in cold water but soluble in hot water ; on cooling a jel is formed. *Iso*lichenin is soluble in cold water. The protein content of Indian lichens varies from 4–20% ; the hydrolysates of some lichens reveal the same amino acid pattern as that of casein hydrolysate. Some lichens contain appreciable quantities of riboflavin, but as a rule, they are poor sources of ascorbic acid. A few contain β-carotene (Asahina & Shibata, 3 ; Mittal & Seshadri, *J. sci. industr. Res.*, 1954, **13A,** 174 ; 1954, **13B,** 244 ; Lal & Rao, ibid., 1956, **15C,** 71).

The tinctorial properties of lichens are due to the presence of lichen acids, some of which (mostly depsides related to orcinol) afford the chromogens from which the colouring matter is derived. Under the combined influence of ammonia and atmospheric oxygen, lecanoric acid and erythrin, present in *Roccellaceae*, give first orcin and subsequently orcein which is the colouring matter of orchil ; if sodium or potassium carbonate is present at the same time, the reaction proceeds further and azolitmin along with erythrolitmin (colouring matters of litmus) are produced. Lichen acids are of value in differentiating species and in relating larger groups. The occurrence of 'chemical strains', i.e. strains which are morphologically indistinguishable but containing different chemical components, seems to be fairly common among lichens (Llano, *Bot. Rev.*, 1944, **10,** 1 ; *Econ. Bot.*, 1956, **10,** 367 ; Thorpe, VII, 372 ; Perkin & Everest, 556–61 ; Seshadri, *Indian J. Pharm.*, 1953, **15,** 286).

There are over 80 lichen substances of known structure, some of which contain hitherto unidentified nuclei. On the basis of chemical structure, they are classified into ten groups, viz. (*i*) monobasic lactonic, dibasic, and tribasic acids, (*ii*) polyhydric (tetra- to hepta-) alcohols, (*iii*) triterpenoids (zeorin series), (*iv*) pulvic acid derivatives, intimately related to phenylbenzoquinone pigments of higher plants, (*v*) depsides consisting of two or three orcinol or β-orcinol carboxylic acids in ester linkage, (*vi*) depsidones (orcinol or β-orcinol type) having a characteristic 7-membered ring with a depside linkage and an oxygen bridge binding two aromatic rings, (*vii*) quinone pigments including anthraquinone derivatives, (*viii*) xanthone derivatives (lichexanthone), (*ix*) dibenzofuran derivatives, and (*x*) diketopiperazine derivatives ; the first three groups belong to the aliphatic series and the rest to the aromatic series. There are many lichen compounds whose chemical nature is unknown (Asahina & Shibata, 5 ; Thorpe, VII, 285).

The number of lichen species recorded throughout the world is estimated at 15,000–16,000, grouped under 60 families and 400 genera. Very little is known about the lichen flora of India ; some 700 species are reported to occur, but species of economic importance are not abundant. Considerable work on the chemistry and utilization of lichens has recently been carried out in India and active schools of research have now come into being. Important Indian lichens are discussed in detail below. Table 1 lists minor Indian lichens, their distribution, chemical composition and uses.

Cetraria islandica (Linn.) Ach. (family *Parmeliaceae* ; Iceland Moss) is an erect or ascending, strap-shaped, somewhat rigid fruticose lichen widely distributed in northern arctic and alpine regions ; it is scarce in alpine Himalayas ; it is pale chestnut brown or dark brown in colour (Information from D. D. Awasthi, Lucknow University).

Iceland moss is used as human food in Scandinavian countries and Iceland in mixture with cereals and mashed potatoes. The comparative values of potato, iceland moss and reindeer moss, based on their carbohydrate contents, is reported to be 1 : 3.4 : 2.5. For consumption, the lichen is soaked with dilute sodium carbonate solution to remove bitter principles (lichen acids) and then dried and reduced

TABLE 1—MINOR INDIAN LICHENS: THEIR DISTRIBUTION, CHEMICAL COMPONENTS AND USES

Species	Distribution	Chemical components	Uses
Alectoria jubata (Linn.) Ach. (*Usneaceae*)[1,2,3]	Himalayas		As food; source of carbohydrate in brewing & distilling; pale green & brown dye
A. virens Tayl.[1,4,5,6]	Himalayas	Vulpinic acid, virensic acid & *d*-arabitol	
Anaptychia ciliaris (Linn.) Korb. (*Physciaceae*)[1,7,8]	Gulmarg (Kashmir)	Atranorin, arabitol & mannitol	As scent & for cleansing & whitening hair
A. ciliaris var. *angustata* Zahlbr.[1]	N. W. Himalayas		Preparation of hair powder
A. hypoleuca Mass.[1,9]	Himalayas	Atranorin (0.2%) & zeorin (0.04%)	
A. leucomelaena var. *angustifolia* Muell.-Arg.[5,9]	Nepal, Sikkim & Kodaikanal (S. India)	Atranorin (2.4, 4.0%) & zeorin (1.0, 1.3%)	
A. speciosa (Wulf.) Mass.[1,9]	Sikkim, Darjeeling & Khasi hills	Atranorin (3.3%) & zeorin (0.75%)	
Caloplaca elegans (Links.) Th. Fr. (*Caloplacaceae*)[5,10]	Nepal & Kashmir	Physcion (0.7%)	
C. murorum (Hoffm.) Th. Fr.[11,2]	Himalayas		Yellow dye
Candelaria concolor Stein (*Parmeliaceae*)[13]	Kashmir	Pulvinic dilactone	
Candelariella vitellina (Ehrb.) Muell. Arg. (*Lecanoraceae*)[11,12,2]	Himalayas	Calycin (o-hydroxypulvic anhydride) & pulvic anhydride	Yellow dye
Cetraria ambigua Bab. (*Parmeliaceae*)[1,5]	Alpine Himalayas	Usnic acid & an acid related to protolichesterinic acid	
C. fahlunensis (Linn.) Schaer.[11,12,2]	Himalayas	Cetraric acid	Red brown dye
C. pinastri (Scop.) Rohl.[1,2,3,12]	N.W. Himalayas	Pinastric acid, usnic acid & vulpinic acid	Green dye; for poisoning wolves in northern Europe
C. thomsonii (Stirt.) Zahlbr.[1,5]	Nepal & East India	Atranorin & alectoronic acid	..
Cladonia alpestris (Linn.) Rabh. (*Cladoniaceae*)[11,7,17,2,3,15,16]	Nepal	Arabitol, mannitol & friedelin	Fodder for reindeer; production of glucose (yield, 74%); hot aq. soln. used in Finland for tuberculosis
C. fimbriata (Linn.) Willd.[11,2]	Himalayas	..	Red-purple dye
C. pyxidata (Linn.) Fr.[11,14,15,16]	Himalayas	Lichenin	Mucilaginous; ash-green dye; expectorant, used for whooping cough
C. sylvatica (Linn.) Hoffm.[5,8]	Nepal		Same as those of *Cladonia alpestris*; essential oil may be used in perfumery
Dermatocarpon moulinsii (Mont.) Zahlbr. (*Dermatocarpaceae*)[1,5,11]	Himalayas		Thallus used as cork substitute for lining insect collection boxes
Diploschistes scruposus Norm. (*Diploschistaceae*)[11,12,1]	Himalayas	Diploschis cid	Brown dye; for calico printing
Gyrophora cylindrica (Linn.) Ach. (*Gyrophoraceae*)[18,2]	Darjeeling		Green-brown dye
G. lecanocarpoides Th.Fr.[1]	Himalayas		Red-brown dye
G. papillosa Nyl.[1]	Himalayas		Red-brown dye
Lecanora calcarea (Linn.) Nyl. (*Lecanoraceae*)[11,2]	Kumaon		Red-brown dye
Lecidea lucida Ach. syn. *Biatora lucida* (Ach.) Fr. (*Lecideaceae*)[13]	Chaubattia & Ranikhet (Kumaon hills)	Leprapinic acid (2-methoxy vulpinic acid) & calycin	

TABLE 1 · *Contd.*

Species	Distribution	Chemical components	Uses
Lepraria candelaris (Linn.) Fr. (*Imperfect Lichen*)[13]	Ootacamund	Pinastric acid	
L. chlorina (DC.) Ach.[13,7,2]	Dharamsala (Punjab)	Leprapinic acid & its methyl ether, calycin, arabitol & mannitol	Brown dye
L. citrina Schaer.[20]	Simla	Leprapinic acid	
L. flava (Schreb.) Ach.[20,21]	Kodaikanal	Pinastric acid, usnic acid, vulpinic acid & calycin	
Lobaria isidiosa Vain. (*Stictaceae*)[5,22]	Temperate Himalayas	Thelephoric acid	
L. pulmonaria (Linn.) Hoffm.[11,18,23,7,24,2,5]	Himalayas & Assam	Arabitol, mannitol & *nor*-stictic acid	Orange & brown dye; in perfumery; tanning material; for cleansing hair & for eczema
L. scrobiculata (Scop.) Ach.[25,2]	Simla		Brown dye
Ochrolechia parella (Linn.) Mass. (*Lecanoraceae*)[11,2]	Scarce in India		Violet dye
Parmelia arnoldii DR. (*Parmeliaceae*)[1,25,2,(a),26]	Himalayas & Kodaikanal	Atranorin, lecanoric acid & salazinic acid	
P. caperata (Linn.) Ach.[11,5,7,2]	Sub-tropical & temperate Himalayas	Arabitol & mannitol	Brown-orange to lemon-yellow dye
P. conspersa (Ehrh.) Ach.[1,18,27,7]	Kashmir & Darjeeling	Salazinic or conspersaic acid, arabitol & mannitol	Red-brown dye; for syphillis in S. Africa
P. conspurcata (Schaer.) Vain. syn. *P. subargentifera* Nyl.[4]	Kashmir	Lecanoric acid	
P. corniculans Nyl.[1]	Mussoorie	Atranorin, lecanoric acid & salazinic acid	
P. furfuracea (Linn.) Ach. syn. *Evernia furfuracea* Mann[11,18].	N.W. Himalayas, Sikkim & Darjeeling	Arabitol & mannitol	Red brown dye; oleoresin used in perfumery
P. himalayensis Nyl.[1,5]	Himalayas	Usnic acid & lecanoric acid	
P. hyporysalea Vain.[28]	Solan (Simla hills)	Atranorin (1.0%) & lecanoric acid (3.0%)	
P. manshurica Asahina[28]	Simla	Atranorin (0.4%) & lecanoric acid (4.0%)	
P. meizospora Nyl.[1]	Dehra Dun	Lecanoric acid & salazinic acid	
P. nilgherrensis Nyl.[25,29]	Himalayas	Atranorin & collatolic acid	
P. nimandaiana Zahlbr.[5,30]	Sikkim & Nepal	Atranorin (0.7%), lecanoric acid (1.1%), gyrophoric acid (1.0%) & salazinic acid (6.4%)	
P. olivacea (Linn.) Nyl.[1,11,2]	Himalayas		Brown dye: calico printing
P. perforata Ach.[1,12]	Assam & Sikkim	Zeorin, atranorin & lecanoric acid	Diuretic
P. perlata (Huds.) Ach.[1,11,29,11]	Temperate Himalayas & West Bengal	Lecanoric acid & atranorin	Astringent, resolvent & diuretic; external application for pain in renal & lumbar regions
P. physodes (Linn.) Ach.[1,7,32,2],	N. W. Himalayas	Atranorin, capraric acid, physodic acid, arabitol & mannitol in traces	Brown dye; mucilage used as substitute for gum arabic in dyeing & in parchment & cardboard
P. pseudohyporysalea Asahina[4]	Dehra Dun & Nepal	Atranorin & gyrophoric acid	
P. quercina (Willd.) Vain.[33,34]	Marudamalai hills (S. India)	Lecanoric acid, atranorin & lichexanthone (0.5%)	May be used as food*

TABLE 1 –*Contd.*

Species	Distribution	Chemical components	Uses
P. saxatilis (Linn.) Ach.[1,2]	N. W. Himalayas		Orange, yellow & red-brown dye; in calico printing
P. soredica Nyl.[28]	Simla	Atranorin (2.7%) & lecanoric acid (3.3%)	
P. stenophylla (Ach.) DR.[4]	Kashmir	*d*-Usnic acid & mannitol	
P. sublaevigata Nyl.[28]	Simla	Atranorin (0.35%) & lecanoric acid (0.01%)	
P. sulcata Tayl.[4]	Dehra Dun	Atranorin, lecanoric acid & salazinic acid	
Physcia pulverulenta (Schreb.) Hampe. (*Physciaceae*)[11,5,2]	Himalayas		Yellow dye
P. setosa (Ach.) Nyl.[1,35,4]	Himalayas & Kodaikanal	Atranorin & volemitol	
Ramalina calicaris (Linn.) Rohl. (*Usneaceae*)[1,5,36,2,3]	West Bengal, Nepal, Chaubattia & Naini Tal	*d*-Usnic acid, sekikaic acid, *d*-arabitol & lichenin	Yellow-red dye; in perfumery
R. farinacea (Linn.) Ach.[11,18,37,7,1]	Himalayas	Usnic acid, sekikaic acid, *nor*-stictic acid & mannitol	Light brown dye; in perfumes & cosmetics
R. fraxinea (Linn.) Ach.[1,2,3]	N. W. Himalayas		Grey-white dye; in perfumes & cosmetics; mucilage used as substitute for gum arabic
R. tayloriana Zahlbr.[24]	Simhachalam hills (Waltair)	*d* Arabitol (0.1%), *d*-usnic acid (0.36%), sekikaic acid (0.9%) & lichenin	Growing parts of sandal trees severely damaged by this lichen
Roccella tinctoria Lam. & DC. (*Roccellaceae*)[1,12,2]	Madras	Lecanoric acid, roccellic acid & erythrin	Preparation of orchil & cudbear
Solorina crocea (Linn.) Ach. (*Peltigeraceae*)[11,12,2]	N. W. Himalayas	Solorinic acid	Yellow dye
Stereocaulon paschale (Linn.) Hoffm. (*Cladoniaceae*)[11,17,2]	Himalayas	Friedelin	Ash-green dye
Sticta crocata (Linn.) Ach. (*Stictaceae*)[11,2]	Himalayas		Source of gamboge; brown dye
Teloschistes flavicans (Swartz.) Norm. (*Teloschistaceae*)[11,24,38,39,2]	Simhachalam hills & Nilgiris	Physcion (2-methyl-4 : 5 di-hydroxy-7-methoxy-anthraquinone), teloschistin (=fallacinol, ω-hydroxyphyscion), fallacinal & vicanicin	Source of gamboge; yellow dye
Umbilicaria pustulata var. *papulosa* Tuck. (*Gyrophoraceae*)[1,12]	N. W. Himalayas	Gyrophoric acid	Red-brown dye
Usnea aspera Vain. (*Usneaceae*)[4]	Devicolam hills (Kerala)	*d*-Usnic acid & psoromic acid	
U. flexilis Stirt.[1,5]	Nepal & Nilgiri hills	Usnic acid & salazinic acid	
U. florida Wiggs[39,2]	Himalayas	Usnic acid, salazinic acid & stictic acid	Green yellow, red brown dye
U. hirta Hoffm.[1,40]	N. W. Himalayas	Usnic acid (1.1%) & salazinic acid (1.2%)	
U. japonica Vain.[21]	Coorg	Usnic acid, stictic acid & barbatolic acid	
U. orientalis Mot.[4,11,34]	Himalayas & Kodaikanal	Kodaikanal species contains *d*-usnic acid, barbatic acid, stictic acid & caperatic acid; Himalayan species contains *d*-usnic acid & salazinic acid	May be used as food*

TABLE 1— *Contd.*

Species	Distribution	Chemical components	Uses
U. sikkimensis Biswas[23]	Darjeeling & Sikkim		Powder used for lung troubles, haemorrhages & asthma; also for strengthening hair
U. stirtoniana Zahlbr.[1,11,34]	Himalayas	*d*-Usnic acid & stictic acid	May be used as food*
U. thomsonii Stirt.[1,5]	Himalayas	Usnic acid & salazinic acid	
U. venosa Mot.[42]	Nilgiri hills	Carotene (4 mg./100 g.), *d*-usnic acid (0.6%), barbatic acid (1.1%), salazinic acid (1.7%) & ergosterol (0.2%)	
Xanthoria parietina (Linn.) Th. Fr. (*Teloschistaceae*)[1,43,2]	Kashmir	Physcion (1.2%), mannitol, lichenin, *iso*lichenin & parietinic acid	Yellow dye

[1] Biswas, *J. R. Asiat. Soc. Beng., Sci.*, 1947, **13,** 75; [2] Llano, *Bot. Rev.*, 1944, **10,** 1; [3] Llano, (*Econ. Bot.*, 1948, **2,** 15; [4] Dhar *et al.*, *J. sci. industr. Res.*, 1959, **18B,** 111; [5] Asahina in Kihara, I, 43, 47, 53 60, 62–63; [6] Information from Prof. T. R. Seshadri, Delhi University; [7] Lindberg *et al.*, *Acta chem. scand.*, 1953, **7,** 591; [8] Uphof, 24, 96, 266; [9] Neelakantan *et al.*, *Indian J. Pharm.*, 1954, **16,** 173; [10] Neelakantan & Seshadri, *J. sci. industr. Res.*, 1952, **11B,** 126; [11] Information from D. D. Awasthi, Lucknow University; [12] Perkin & Everest, 531 32, 536, 539 41; [13] Grover & Seshadri, *J. sci. industr. Res.*, 1959, **18B,** 238; [14] des Abbayes, *Candollea*, 1957–58, **16,** 201; [15] Llano, *Econ. Bot.*, 1956, **10,** 367; [16] Bustinza, ibid., 1952, **6,** 402; [17] Bruun, *Acta chem. scand.*, 1954, **8,** 71; [18] Chopra, G. I., 30, 46, 58, 60, 63–65; [19] Wren, 117; [20] Mittal & Seshadri, *J. chem. Soc.*, 1955, 3053; [21] *Chem. Abstr.*, 1954, **48,** 9969; [22] Seshadri, *Indian J. Pharm.*, 1953, **15,** 286; [23] Biswas, 98; [24] Seshadri & Subramanian, *Proc. Indian Acad. Sci.*, 1949, **30A,** 15, 62, 67; [25] Awasthi, *Proc. Indian Sci. Congr.*, 1953, pt III, 72; [25(a)] Awasthi, *Curr. Sci.*, 1957, **26,** 123; [26] Shah, *J. Indian chem. Soc.*, 1954, **31,** 253; [27] Watt & Breyer-Brandwijk, 215; [28] Aghoramurthy *et al.*, *J. sci. industr. Res.*, 1954, **13B,** 326; [29] Rangaswami & Rao, *Indian J. Pharm.*, 1955, **17,** 50, 70; [30] Rangaswami & Rao, *J. sci. industr. Res.*, 1954, **13B,** 403; [31] Kanny Lal Dey, 229; [32] *Chem. Abstr.*, 1953, **47,** 6001; [33] Aghoramurthy & Seshadri, *J. sci. industr. Res.*, 1953, **12B,** 73, 350; [34] Lal & Rao, ibid., 1956, **15C,** 71; [35] Awasthi, *J. Indian bot. Soc.*, 1960, **39,** 1; [36] Mittal *et al.*, *J. sci. industr. Res.*, 1952, **11B,** 386; [37] Rangaswami & Rao, *Indian J. Pharm.*, 1954, **16,** 197; [38] Rajagopalan & Seshadri, *Proc. Indian Acad. Sci.*, 1959, **49A,** 1; [39] Seshadri *et al.*, *Tetrahedron Lett.*, No. 9, 1959, 1; [40] Rangaswami & Rao, *Indian J. Pharm.*, 1954, **16,** 151; [41] Neelakantan, Ph.D. Thesis, Delhi University, 1955; [42] Murty & Subramanian, *J. sci. industr. Res.*, 1959, **18B,** 394; [43] *Chem. Abstr.*, 1958, **52,** 14576.

* Analyses of *Parmelia quercina, Usnea orientalis* and *U. stirtoniana* gave respectively the following values: crude protein, 12.8, 5.1, 4.6; ether extr., 4.5, 1.6, 2.0; lichenin (*iso*lichenin), 25.0, 50.0, 36.0; crude fibre, 10.7, 6.1, 3.7; and ash, 2.4, 8.9, 2.9%; calcium, 1,250, 902, 773; phosphorus, 195, 110, 90; iron, 272, 314, 30; ascorbic acid, 2.7, 9.4, 4.5; and riboflavin, 0.53, 0.08, 0.16 mg./100 g. (Lal & Rao, *J. sci. industr. Res.*, 1956, **15C,** 71).

to powder. It is consumed in the form of bread, porridge or gruel. Iceland moss is also used as feed for cattle, pigs and ponies. It contains: lichenin (40%) and *iso*lichenin (10%); among the minor constituents present mention may be made of arabitol, mannitol, trehalose, sucrose, umbilicin, fumarprotocetraric acid, protolichesterinic acid, usnic acid and a triterpenoid, friedelin (Llano, *Bot. Rev.*, 1944, **10,** 1; *Econ. Bot.*, 1948, **2,** 15; Wallis, 291; Bustinza, *Econ. Bot.*, 1952, **6,** 402; Lindberg *et al.*, *Acta chem. scand.*, 1953, **7,** 591; Bruun, ibid., 1954, **8,** 71).

Iceland moss is almost odourless and has a bitter, mucilaginous taste. It possesses demulcent and laxative properties and is given in decoction as a bitter tonic and nutrient in chronic catarrh, chronic bronchitis and consumption. It is used as a substitute for salve bases in the preparation of emulsions and in the reduction of bitter taste in certain drugs; it is also used as a culture medium in the laboratory (Wallis, 290; Trease, 114; Wren, 183; Llano, *Bot. Rev.*, 1944, **10,** 1; *Econ. Bot.*, 1948, **2,** 15).

Iceland moss may be used as a source of glucose and also for the production of alcohol. It is used for tanning and dyeing (Llano, *Bot. Rev.*, 1944, **10,** 1; *Econ. Bot.*, 1948, **2,** 15; 1956, **10,** 367).

Cladonia rangiferina (Linn.) Web. (family *Cladoniaceae*; REINDEER MOSS) is a fruticose lichen with primary thallus of greyish granules which soon disappear. Podetia prominent, cylindrical, erect, subcorymbose, greyish green or whitish. It is recorded from Sikkim (Biswas, *J. R. Asiat. Soc. Beng., Sci.*, 1947, **13,** 75; Information from D. D. Awasthi, Lucknow University).

Reindeer moss constitutes the chief food of reindeer in arctic and sub-arctic regions where it grows in cushions or carpet-like mats extending over many miles. Like *Cetraria islandica*, it may be used for the production of glucose and alcohol. It contains usnic acid, fumarprotocetraric acid and atranorin. In Finland, a hot aqueous solution of the lichen is said to be used for tuberculosis. It yields an iron-red dye (Llano, *Bot. Rev.*, 1944, **10,** 1; Bustinza, *Econ. Bot.*, 1952, **6,** 402; Perkin & Everest, 532; Asahina & Shibata, 140).

T. R. Seshadri, Delhi University

FIG. 35. PARMELIA TINCTORUM—A FOLIOSE LICHEN

Parmelia abessinica Kremp. (family *Parmeliaceae*; TEL.— *Rathipoovvu*) is a crustaceous lichen found in rocky areas of Bellary, Anantapur and Cuddapah districts (Andhra State). The lichen is available in large quantities in the market and used as food material and condiment (Sastry & Seshadri, *Proc. Indian Acad. Sci.*, 1942, **16A**, 137; Neelakantan & Seshadri, *J. sci. industr. Res.*, 1952, **11A**, 338).

P. abessinica contains atranorin (1.1%), lecanoric acid (3.3%), salazinic acid (0.1–0.5%) and *iso*lichenin (3.4%). Owing to its high content of lecanoric acid, this lichen is a satisfactory source for the production of orcinol and litmus (Sastry & Seshadri, loc. cit.; Sastry & Rao, *Curr. Sci.*, 1941, **10**, 437).

Parmelia cirrhata Fr. syn. *P. kamtschadalis* Eschew. is a foliose lichen widely distributed in the temperate Himalayas; it is also recorded from hills of S. India. It may be used as food. An analysis of the lichen gave the following values: crude protein, 8.2; ether extr., 2.6; lichenin (*iso*lichenin), 22.5; crude fibre, 11.0; and ash, 12.3%: calcium, 398 mg.; phosphorus, 156 mg.; iron, 52 mg.; ascorbic acid, 4.4 mg.; and riboflavin, 210 μg./100 g. (Awasthi, *Proc. Indian Acad. Sci.*, 1960, **51B**, 169; Asahina in Kihara, I, 52; Lal & Rao, *J. sci. industr. Res.*, 1956, **15C**, 71).

P. cirrhata contains atranorin (0.6%), salazinic acid (2.9%) and *d*-protolichesterinic acid (0.6%). It yields a pale rose dye and is used for printing and perfuming calico. It possesses astringent, resolvent and aperient properties; its powder is used as cephalic snuff (Aghoramurthy *et al.*, *J. sci. industr. Res.*, 1954, **13B**, 326).

Parmelia tinctorum Despr. is a foliose lichen common in the plains of India and in the Himalayas on tree bark and rocks. It is commonly used in certain parts of S. India as a component of various food preparations. An analysis of it gave the following values: crude protein, 13.8; ether extr., 6.0; lichenin (*iso*lichenin), 25.0; crude fibre, 13.4; and ash, 12.6%: calcium, 1,728 mg.; phosphorus, 118 mg.; iron, 36 mg.; ascorbic acid, 5.0 mg.; and riboflavin, 100 μg./100 g. (Information from D. D. Awasthi, Lucknow University; Biswas, *J. R. Asiat. Soc. Beng., Sci.*, 1947, **13**, 75; Asahina in Kihara, I, 54; Mittal & Seshadri, *J. sci. industr. Res.*, 1954, **13A**, 174; Lal & Rao, ibid., 1956, **15C**, 71).

The chemical composition of the lichen varies markedly according to the locality from which it is

T. R. Seshadri, Delhi University

FIG. 36. PELTIGERA CANINA—A FOLIOSE LICHEN

collected. A sample from Coorg contained lecanoric acid (5.0%), atranorin (0.8%) and *nor*-stictic acid (1.0%), while samples from Chaubattia (Kumaon hills) and Mysore contained salazinic acid, besides atranorin and lecanoric acid. Some samples of lichen contain as high as 20–25% lecanoric acid, though the bulk of Indian specimens contains *c.* 5.0%. This lichen forms a convenient source of orcinol used as a starting material in a number of syntheses and as a stain for micro-organisms (Neelakantan *et al.*, *J. sci. industr. Res.*, 1951, **10B,** 199; Seshadri & Subramanian, *Proc. Indian Acad. Sci.*, 1949, **30A,** 62; Seshadri & Venkatasubramanian, *Res. & Ind.*, 1957, **2,** 85).

Peltigera canina (Linn.) Willd. (family *Peltigeraceae*) is a large spreading, rather thick foliose lichen with rounded lobes found in the temperate Himalayas. It may be used as food. An analysis of the lichen gave the following values: crude protein, 21.3; ether extr., 0.1; crude fibre, 17.5; and ash, 8.7%: calcium, 486 mg.: phosphorus, 235 mg.: iron, 49 mg.: ascorbic acid, 4.4 mg.: and riboflavin, 430 μg./100 g.: it is reported to contain ergosterol (Information from D. D. Awasthi, Lucknow University; Biswas, *J. R. Asiat. Soc. Beng., Sci.*, 1947, **13,** 75; Lal & Rao, *J. sci. industr. Res.*, 1956, **15C,** 71; Llano, *Econ. Bot.*, 1956, **10,** 367).

Prof. T. R. Seshadri, Delhi University

FIG. 37. RAMALINA SINENSIS—A FRUTICOSE LICHEN

Prof. T. R. Seshadri, Delhi University

FIG. 38. ROCCELLA MONTAGNEI—A FRUTICOSE LICHEN

P. canina yields an iron-red dye. An infusion of the lichen is considered tonic, deobstruent, and slightly purgative and is used for liver complaints (Llano, *Bot. Rev.*, 1944, **10,** 1; Steinmetz, II, 334; Wren, 216).

Ramalina sinensis Jatta (family *Usneaceae*) is a fruticose lichen with thin deeply laciniate thallus recorded from Nepal and Naini Tal. It may be used as food. An analysis of the lichen gave the following values: crude protein, 6.8; ether extr., 0.2; lichenin (*iso*lichenin), 52.0; crude fibre, 4.1; and ash, 4.6%: calcium, 1,022 mg.; phosphorus, 150 mg.; iron, 81 mg.; ascorbic acid, 6.3 mg.: and riboflavin, 140 μg./100 g. The lichen contains *d*-usnic acid (0.5%) and *d*-arabitol (0.4%) (Asahina in Kihara, I, 61; Awasthi, *Proc. Indian Acad. Sci.*, 1960, **51B,** 169; Mittal *et al.*, *J. sci. industr. Res.*, 1952, **11B,** 386; Lal & Rao, ibid., 1956, **15C,** 71).

Roccella montagnei Bel. (family *Roccellaceae*) is a fruticose lichen found commonly on the east coast; it is abundant in Waltair and neighbouring areas on a variety of trees (Neelakantan & Seshadri, *J. sci. industr. Res.*, 1952, **11A,** 338).

This lichen contains roccellic acid, lecanoric acid, erythrin, orcinol, erythritol, montagnetol and *iso*-lichenin. Considerable variation, both qualitative and quantitative, is observed in the composition of lichen collected from different localities (Rao & Seshadri, *Proc. Indian Acad. Sci.*, 1940, **12A,** 466; 1941, **13A,** 199; Sastry & Rao, *Curr. Sci.*, 1941, **10,** 437).

R. montagnei is a good fodder lichen and may also be used as food. An analysis of the lichen gave the following values: crude protein, 14.2; ether extr., 1.0; lichenin (*iso*lichenin), 15.0; crude fibre, 12.9; and ash, 4.4%: calcium, 394 mg.; phosphorus, 145 mg.; iron, 46 mg.; ascorbic acid, 3.7 mg.; and riboflavin, 750 μg./100 g. It is rich in riboflavin and β-carotene and contains appreciable amounts of ergosterol. The carotene content varies according to the locality from which the lichen is collected: air-dried samples from southern Travancore contained *c.* 40 mg./100 g., whereas those from Waltair contained 28 mg./100 g. A simple method for the separation of carotene from the lichen has been worked out (Neelakantan & Seshadri, *J. sci. industr. Res.*, 1952, **11A,** 338; Lal & Rao, ibid., 1956, **15C,** 71; Seshadri & Subramanian, *Proc. Indian Acad. Sci.*, 1949, **30A,** 15; Murty & Subramanian, *J. sci. industr. Res.*, 1958, **17C,** 105; 1959, **18B,** 91, 162).

Usnea longissima Ach. (family *Usneaceae*) is a filamentous, greatly elongated, pendulous lichen common in temperate and alpine Himalayas on trees (Information from D. D. Awasthi, Lucknow University; Asahina in Kihara, I, 58; Biswas, *J. R. Asiat. Soc. Beng., Sci.*, 1947, **13,** 75).

Prof T. R. Seshadri, Delhi University

FIG. 39. USNEA LONGISSIMA—A FILAMENTOUS LICHEN

The lichen is soft and is used locally for filling cushions. It may be used also as food. An analysis of the lichen gave the following values: crude protein, 5.4; ether extr., 2.2; lichenin (*iso*lichenin), 46.3; crude fibre, 3.8; and ash, 3.5%: calcium, 1,028 mg.; phosphorus, 80 mg.; iron, 90 mg.; ascorbic acid, 3.4 mg.; and riboflavin, 310 μg./100 g. The lichen is reported to be used in China as an expectorant and in the treatment of ulcers. Indian samples contain a high percentage of usnic acid (3–4); they also contain barbatic acid and arabitol. Usnic acid and barbatic acid possess marked anti-tubercular activity; the latter also produces haemolysis (Neelakantan & Seshadri, *J. sci. industr. Res.*, 1952, **11A,** 338; Lal & Rao, ibid., 1956, **15C,** 71; Dhar *et al.*, ibid., 1959, **18B,** 111; Mittal & Seshadri, ibid., 1954, **13B,** 244; Bustinza, *Econ. Bot.*, 1952, **6,** 402; Seshadri, *Indian J. Pharm.*, 1953, **15,** 286; Pereira & Bhatnagar, ibid., 1953, **15,** 287).

Licorice—*see* **Glycyrrhiza**

LICUALA Wurmb. (*Palmae*)

A genus of low palms found in tropical Asia, Australia and Pacific Islands. Four species occur in India including two introduced species grown in gardens for ornament.

L. peltata Roxb.

D.E.P., IV, 639; Fl. Br. Ind., VI, 430; Blatter, 88, Pl. XXIII.

Beng. *Kurud, kurkuti.*

Assam—*Patti, chatta-pat*; Lepcha -*Tale lama*; Andamans—*Kapadah.*

A gregarious fan-leaved palm, 1.5–4.5 m. high, found in the hot valleys of North Bengal, lower Sikkim, Assam, Khasi, Naga and Lushai hills, Orissa and Andaman Islands. Leaves orbicular, 0.9 1.5 m. in diam., peltate, 12–30 partite: segments variously connate, many-toothed at the apex; petiole 1.8–2.1 m. long, triangular, armed with stout, curved, black spines; flowers numerous on short stalks, greenish white; fruit ellipsoid, 1.25 cm. long, orange-coloured, one seeded.

L. peltata is grown in gardens for ornament. The leaves are used in Assam for covering palanquins and roofs of boats, and also for making rain hats and umbrellas. They are used for thatching after stripping the petioles and fastening to slivers of bamboo (Firminger, 307; Bor, 348; Parkinson, 269; Gamble, 733).

L. spinosa Wurmb.

Fl. Br. Ind., VI, 431 ; Blatter, 93, Pl. XXXII.

HINDI—*Jungli selai.*

A densely tufted palm with many stems found in the Andaman Islands, Java and Malacca. It is smaller than *L. peltata* and occurs in swampy places and outskirts of tidal forests near the sea shore. It is often grown in gardens for ornament. The leaves of the palm, like those of *L. peltata*, are used for thatching purposes. The bark is reported to be an ingredient of drugs used in Cambodia for the treatment of tuberculosis. Alcohol and chloroform extracts of the leaves show slight indication of inhibition against *Mycobacterium tuberculosis* (Burkill, II, 1342 ; Parkinson, 269 ; Brown, 1941, I, 309 ; Caius, *J. Bombay nat. Hist. Soc.*, 1934–35, **37,** 934 ; Masilungan *et al., Philipp. J. Sci.*, 1959, **88,** 245).

Licury Wax—*see* **Cocos**

Lignaloe Tree—*see* **Bursera**

LIGNITE

Lignite is the name applied to unconsolidated coal, below sub-bituminous rank. It represents a stage in the transformation of buried plant tissues into black coal by compression and consolidation, and forms a connecting link between peat and bituminous coal.

Lignite is readily distinguished from coal by its brown colour and amorphous, fibrous or woody texture. It contains 20–60% moisture (as mined basis) which is lost on exposure to air, and the mass shrinks and crumbles to powder. Lignite also contains 5–15% resin or wax. It burns with little or no smoke. The calorific value of moisture-free lignite ranges from 6,000 to 7,000 B.t.u./lb.

Depending on the appearance, lignites may be classified as: earthy brown or fibrous lignite, approaching peat in appearance and properties ; woody or xylitic lignite, consisting largely of coalified wood and retaining woody structure ; and amorphous brown coal having a darker shade than the other two. On the basis of resin or wax content lignites may be classified as: waxy lignite, containing a comparatively high proportion of montan wax or related compound and a relatively low quantity of resin ; resinous lignite, containing appreciable quantities of resin along with montan wax ; and non-waxy, fibrous or woody lignite, containing little or no wax.

Lignites are widely distributed in all the continents, except possibly Antarctica. The occurrences in North America and Europe are extensive. In India, lignite occurs in the States of Gujarat, Kashmir, Kerala, Madras and Rajasthan, and also in Siwaliks and Pleistocene of the Himalayan regions. All the occurrences are of the Tertiary age.

DISTRIBUTION

Gujarat—Lignite occurs in Kutch, in association with rocks of the Eocene age (Laki series) near Umarsar (23° 44′ : 68° 51′), Lefri (23° 30′ : 69° 1′), Jhulrai (23° 31′ : 68° 51′), and Baranda (23° 31′ : 68° 48′). The Umarsar deposit consists of 5 or 6 seams of brown to dark brown resinous lignite. The top seam has a max. thickness of 10 ft. with an overburden of 100 ft. ; the one below has a max. thickness of 18 ft. ; others are relatively thin, ranging from 1 to 3 ft. The seams are practically horizontal with rolling dips and the inferred reserves in the top two seams are 4–4.3 million tons. A lignite seam (length 200 ft., max. thickness 5 ft.) has been located *c.* 3/4 mile north-west of Lefri. The lignite is of rather poor quality ; the reserves in this area are estimated at 134,000 tons. A seam 4–6 ft. thick occurs near Jhulrai ; the reserves are estimated at 1.4 million tons. The lignite deposit near Baranda is hardly 2 ft. thick and is not of much economic importance. According to recent reports the estimated reserves in the Kutch region are at 11 million tons [Poddar & Venkatappayya, *Unpublished Final Rep. on Coal and Lignite Deposits of Kutch*, Geol. Surv. India, 1953 ; *Iron & Steel Rev.*, 1960–61, **4**(4), 48].

Sizable deposits of lignite have recently been found at Bhuri and in the region between the Narbada and the Tapti rivers in Broach and Surat districts. According to preliminary investigations the deposits appear to be of a similar extent as the Kutch deposits. The lignite obtained is reported to be of fairly good quality [*Iron & Steel Rev.*, 1960–61, **4**(4), 48].

Kashmir—Lignite beds occur in Middle Karewas, which are late Tertiary formations of the Pliocene age. Two lignite horizons have been recognized in the Shaliganga river–Ferozepore nala sector. The Karewas in this sector show pronounced folding resulting in steep dips and repetition of outcrops ; the folding disappears to the west of Srinagar–Tangmarg road and the beds flatten out. The upper horizon is completely eroded ; it carries a thin band of lignite, 3–6 in. thick ; the reserves of lignite are insignificant and quality is poor. The lower horizon 300 ft. below, consists of two seams, 1 ft. 6 in. and 2 ft. thick, in the Arigam (33° 56′ : 74° 41′)–Narigund (33° 55′ : 74° 40′) area. The lower seam splits

into 3 seams further to the north-west of Shaliganga area. The lignite seams in the lower horizon have an aggregate thickness of 5 ft. 7 in. within about 18 ft. of strata near Reram; the aggregate thickness increases to 8 ft. 9 in. at Nagbal (34° 6′ : 74° 23′) within 68 ft. of strata and to 9 ft. near Malapur within 21 ft. of strata. A few bands in the lower horizon near Tangmarg contain lignite of usable quality; the ash content, however, is high (40%).

Two well-defined lignite horizons are found in the Nichahom (34° 23′ 30″ : 74° 9′) area. Three seams, 5 ft. 8 in., 3 ft. 5 in., and 4 ft. 9 in. thick, have been proved in the upper horizon and at least one seam with a thickness of 5 ft. occurs in the lower horizon. The horizons continue further to the north-west in the Chokibal area; both horizons have been traced at Honginkut (34° 27′ 10″ : 74° 5′ 30″) in Kanahom Nar. The reserves in the Nichahom–Chokibal area, within a depth of 5 times the thickness of the lignite horizons, are estimated at 35 million tons [Mehta, *Indian Min. J.*, 1957, **5**(10), 58].

The total reserves of lignite in the Kashmir valley are estimated at 128 million tons; reserves of workable deposits are, however, limited. Steps are being taken to exploit the deposits of Tangmarg and Nichahom-Chokibal areas [*Mineral Production in India*, Indian Bureau of Mines, 1957, 42; *J. Min. Metals & Fuels*, 1959, **7**(3), 32].

Kerala—Lignite occurs at Cannanore (11° 52′: 75° 22′), Beypore (11° 10′ : 75° 47′) and Varkkallai (8° 44′ : 76° 43′). The last deposit, which extends over a wide area between Quilon and Palaikkal, is promising. The thickness of the seam varies from 25 ft. to 40 ft. and the reserves have been estimated at 270 million tons. Actual exposure of lignite is limited to the coastal strip near Varkkallai. Detailed investigation by boring Tertiary sediments is necessary to assess the reserves in the area [*Rec. geol. Surv. India*, 1950, **83**(1), 136].

Madras—The largest known lignite deposit in the country occurs in the neighbourhood of Neyveli (79° 29′ : 11° 32′) in South Arcot dist. Lignite was first noted in this area in 1934; systematic drilling, carried out during 1943–46 and 1948–51, proved the existence of extensive deposits of lignite with an estimated reserve of 2,000 million tons.

The Cuddalore sandstones of Miocene age associated with the lignite deposit are composed of soft, often water-logged grit with clays of variegated colour rich in alumina. The lignite bed occurs 140 ft. below the surface, as a regular seam varying in thickness from a few inches to 90 ft. The bed has a low dip towards ESE and shows a tendency to thicken in this direction. The overburden: lignite ratio varies from 2:1 to 24:1 with an average of 9:1.

The lignite bed is sandwiched between high pressure artesian aquifers, the bottom one being the more powerful. The aquifer consists largely of porous pebbly sandstones, varies in thickness and character from area to area, and occurs mostly within 50–100 ft. of the lignite bed, though at some places it is in direct contact. The lignite bed is mostly sealed off from aquifers by layers of impervious clay. The high pressure aquifer occurs within 300–350 ft. from the surface.

The lignite varies in colour from brown to dark brown and has a non-banded granular texture. Microscopic studies indicate that it is composed of a wide variety of plant ingredients mainly of coniferous origin. The attritus consists of compressed woody tissue and cuticular coverings of leaves, fruits and resinous matter, and occasionally small quantities of light resinous bodies, probably of a waxy nature. Most of the attritus is translucent in thin sections; fusain is occasionally found as opaque matter.

The proved lignite field lies between latitudes 11° 24′ and 11° 37′ and longitudes 79° 24′ and 79° 33′, in Vridhachalam, Chidambaram and Cuddalore taluqs. The field is *c.* 14 miles along the NNE–SSW direction and 7 miles in the WNW–ESE direction. The northern and north-western limits of the field are known, but its extension to east and south, where the lignite is expected to occur at deeper levels, is still to be proved.

Boreholes in the northern part of the field proved an area of about 5½ sq. miles in which the lignite bed has an av. thickness of 55 ft. and an overburden of 180 ft. This area being on the extreme rise of the seam encounters less pressure from artesian water than other areas and has been chosen for mining by the open cut method.

Lignite also occurs along the coastal tracts between Pondicherry and Cuddalore. Deposits are located at Bahur (11° 48′ : 79° 44′ 30″), 5 miles NNW of Cuddalore, Aranganur (2½ miles north of Bahur), and Kanniyakovil (3 miles north of Cuddalore). At Bahur, a 35 ft.-seam occurs at a depth of 275 ft. At Aranganur, two seams have been observed, the upper, 27 ft. thick at a depth of 203 ft. and the lower, *c.* 5 ft. thick at a depth of 297 ft. A 50 ft.-seam was encountered at a depth of 330 ft. at Kanniyakovil. Assuming that the same seam has been touched in boreholes

sunk at these places, it is calculated that the seam has a SSE dip of 50 ft./mile (Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 164).

Cuddalore sandstones associated with the Neyveli lignite deposits also occupy large areas in Tiruchirapally, Tanjore and Ramnad districts along the coastal tract. Detailed investigation will be necessary to ascertain whether lignite occurs, in exploitable quantities, in these areas.

Rajasthan—In Bikaner division, lignite occurs at Palana (27° 51′ : 73° 19′), Madh (27° 56′ : 73° 33′), Khari (27° 58′ : 73° 57′), Chaneri (27° 45′ : 72° 48′) and Gangasarowar (27° 56′ : 72° 54′). Of these, the Palana occurrence, 12–13 miles south-west of Bikaner city, is the most important. The lignite seam appears to be of half-saucer shape, varying in thickness from a few inches to 2 ft. on the edges to 22–40 ft. towards the centre, then abruptly disappearing against *mitti* pocket running along the whole length of the bed. The seam is 2.5 miles long and has a NW–SE trend, with a dip of 10–15° from the edges to the centre. The bed occurs 140–260 ft. below the surface in association with nummilitic limestones and sandstones of Eocene age (Laki series).

Thin bands of lignite are found at Madh and Gangasarowar below the surface. At Khari, a 3 ft.-lignite seam occurs 105 ft. below the surface. At Chaneri, a 5 ft.-bed of fairly good quality lignite has been found at a depth of 180 ft.; the bed shows indications of thickening towards the east. As the entire area is covered by desert sand, it is difficult to ascertain (in the absence of borehole data) whether the seam is continuous between Palana and Madh or in the direction of Chaneri. There are, however, possibilities of an extensive bed, though of variable thickness, underlying a large area in western Bikaner and possibly also in Jodhpur and Jaisalmer divisions [Bhattacharya, *Indian Min. J.*, 1955, **3**(9), 105; Heron, *Trans. Min. geol. Inst. India*, 1935, **29,** 333; Sethi, 6; Roy, *Mem. geol. Surv. India*, 1959, **86,** 110].

The colour of Palana lignite varies from typical brown to greyish brown; it is non-banded and granular. Microscopic studies of thin sections indicate the presence of finely divided, light yellow material derived from plant cuticles; there is a larger concentration of resinous bodies in Palana lignite than in South Arcot lignite; opaque attritus, possibly fusain, is present in very small amounts.

Lignite mining around Palana was started in 1898 and continued till 1956, when due to uneconomic working conditions and frequent underground fires, mining was suspended. More than one million tons of lignite have been won from the area. The total reserves of lignite in the Palana area are estimated at 20.5 million tons. A deposit of about 15 million tons of lignite is expected to be located at the neighbouring site of Desnok [*Mineral Production of India*, Indian Bureau of Mines, 1957, 42; *Indian Miner.*, 1960, **14**(2), 164].

For exploiting the two lignite deposits at Palana, a project has recently been drawn up by an expert committee appointed by the Government of India. The project envisages quarrying, by open cast method, about 42,000 tons of lignite per month from the till recently worked seam. The overburden removal operation for exposing an area of 1,510 ft. × 210 ft. × 40 ft. at the first instance, is expected to start by April 1962. The quarrying operation is likely to start in 1963. For assessing the feasibility of exploiting the adjoining thinner lignite seam by underground gasification, the committee has suggested that suitable technical advice may be sought.

Mining

Lignite is usually mined by open cast operation. Underground mining by the conventional pillar-and-stall method was pursued at Palana from 1898–1956 but was given up as it proved to be uneconomic. In Kashmir, lignite is quarried by open cast method.

Underground gasification of lignite and piping the gas to a power generating station has been tried in U.S.S.R.

For the exploitation of lignite deposits in South Arcot, open cast mining has been started on a limited scale by the State-owned *Neyveli Lignite Corporation (Private) Ltd.* The Second Plan envisaged the mining of 3.5 million tons of lignite per year, of which 1.5 million tons were to be consumed for generating power in a thermal station of 250,000 kW. capacity, 1.5 million tons were to be utilized for producing 380,000 tons of carbonized briquettes and the rest for producing 152,000 tons of urea fertilizer (with a fixed nitrogen content of 70,000 tons). Production of lignite is expected to commence on a commercial scale by 1962.

The Third Plan envisages the completion of the programme included in the Second Plan, expansion of thermal power plant capacity to 400,000 kW., and stepping up of the output of lignite from 3.5 million tons to 4.8 million tons, in order to meet the fuel requirements of the expanded thermal power plant.

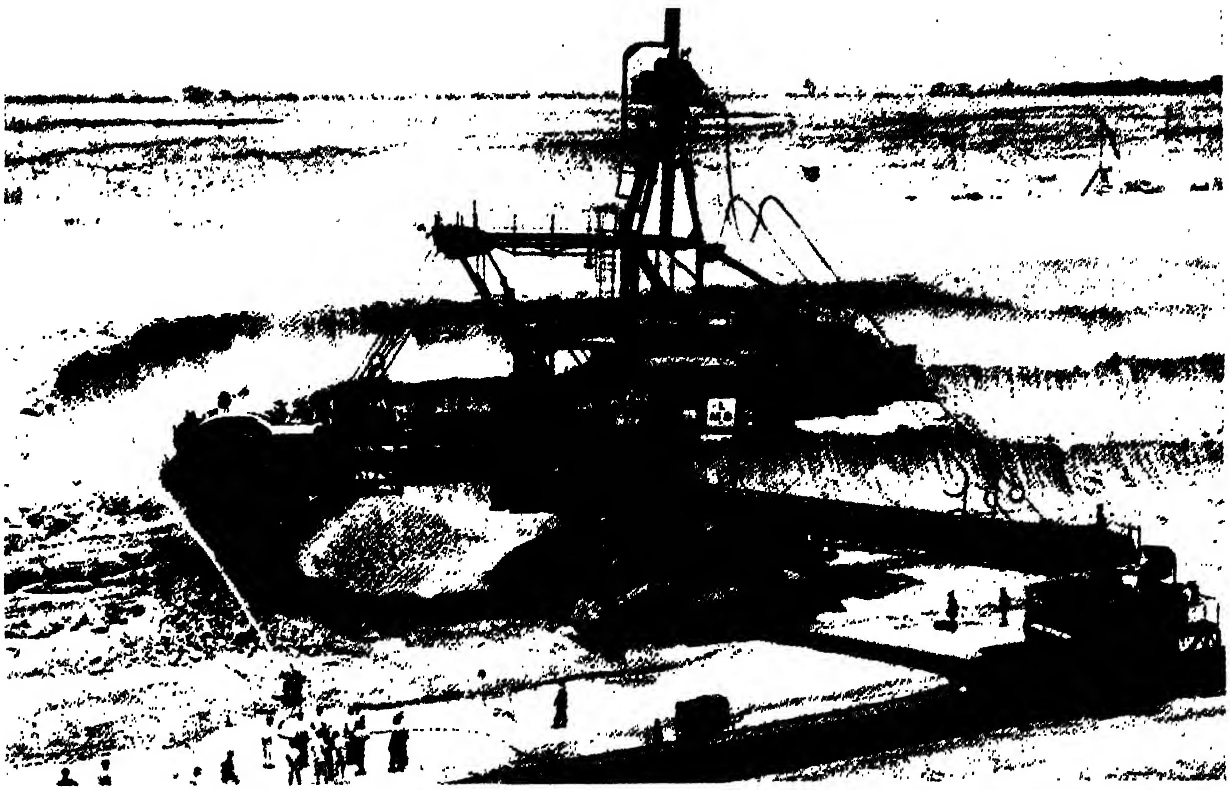


Photo: Neyveli Lignite Corporation

FIG. 40. EXCAVATOR REMOVING OVERBURDEN AT NEYVELI

Work has been started in a mining area of c. 5½ sq. miles with a reserve of 200 million tons of lignite. The area has been divided into a number of sectors, on the basis of available lignite, overburden: lignite ratio, and nature of overburden; each sector is being worked according to a definite plan.

On the basis of the results of large scale pumping tests completed in 1956, forty-eight thousand gallons of water from the artesian aquifers will have to be pumped out per minute from 48 wells, to maintain the pressure of aquifers at a safe level below the lignite bed. The water will be used for boiler feed and cooling purposes in the thermal power station and also for irrigation and potable purposes.

Composition and Uses

The chemical composition of air-dried samples of lignites from Neyveli, Umarsar, Palana and Kashmir deposits is given in Table 1.

The ash contents of Kashmir lignites are usually high and in most cases, the ash is intimately associated with coaly matter. Germanium is present in

TABLE 1—ANALYSES OF AIR-DRIED LIGNITES FROM INDIAN DEPOSITS*

	South Arcot	Umarsar (Kutch)	Palana	Kashmir
Proximate analyses				
Moisture, %	10.5 15.3	18.20	26.7–33.4	6.5 19.2
Ash, %	3.8 6.7	15.40	4.4 6.1	37.9–38.6
Volatile matter, %	42.7–45.5	35.50	34.3 45.2	22.3–27.0
Fixed carbon, %	35.8–39.8	30.90	23.7–26.2	15.2–33.3
Ultimate analyses				
Carbon, %	53.79 59.05	46.05	52.32†	26.38–42.19
Hydrogen, %	3.71–3.99	3.51	4.74	1.75–2.43
Oxygen, %	17.76†	13.60	8.81	5.80†
Nitrogen, %	0.55 0.94	0.62	0.91	0.30 0.84
Sulphur, %	0.72 1.13	3.10	1.68	0.33–1.77
Calorific val., B.t.u./lb.	9,566 9,850	8,740	9,740	6,660†

* Based on analyses carried out at the Central Fuel Res. Inst., Jealgora. †Analysis of one sample only.

traces (<0.002%) and a relatively high proportion of vanadium (220 p.p.m.) is obtained. Analysis of ash from a sample of South Arcot lignite gave the following values: CaO, 24.08; Al_2O_3, 21.3; MgO, 5.14; Fe_2O_3, 4.13; TiO_2, 2.13; SiO_2, 18.00; P_2O_5, 0.10; SO_3, 24.20; and alkali (as K_2O), 0.92%. Beryllium and yttrium occur in detectable quantities; germanium is present in fair traces. The mineral matter of South Arcot lignite is composed mainly of kaolinite, gypsum, quartz and hydrated oxides of aluminium and iron; pyrites are also present. The ash constituents of Palana lignite are the following: CaO, 22.4–22.74; Al_2O_3, 6.46–6.96; MgO, 10.67–11.36; Fe_2O_3, 14.68–15.18; SiO_2, 6.08–11.09; SO_3, 22.98–33.70; K_2O, 2.19; and Na_2O, 3.04%.

South Arcot lignite contains c. 10% crude montan wax. Extraction with alkali yields 55% humic acid.

Lignite is a low grade fuel usable for almost all purposes for which coal is used. As the mined material contains 40–50% moisture, it needs to be dried before use; in this process, lignite loses coherence and disintegrates into powder. For power generation, lignite can be used in pulverized form in specially designed boilers without further processing. Sized semi-dried lignite can also be used in step-grate or trough-grate boilers. Where the power station is situated near the lignite mine, it is advantageous to use the fuel in pulverized form; Kramer mills are used for drying, crushing and conveying lignite in one operation. When the power station is situated at a distance from the mine, dried lignite is supplied in the form of briquettes.

Briquetting of lignite—Lignite is briquetted by pressing the dry powder in moulds under pressure (800–2,000 kg./sq. cm.). The briquettes (moisture content, 12–17%) are fairly stable and can be handled and stored without disintegration or transported over long distances.

Raw briquettes may be subjected to low temperature carbonization to obtain highly stable carbonized briquettes (moisture content, 4%) suitable for use as domestic smokeless fuel.

Briquettes carbonized at 600° have calorific values comparable to those of bituminous coals. Comparative values for moisture, ash, volatile matter, fixed carbon and calorific value of coal, raw lignite and briquetted lignites are given in Table 2.

TABLE 2—COMPARISON OF COAL AND BRIQUETTED LIGNITE*

	Jharia coal	Raw lignite	Raw briquettes	Low carbonized briquettes
Moisture, %	2.0	50.0	12.0	4.0
Ash, %	15.6	3.0	5.3	5.2
Volatile matter, %	19.2	24.8	43.6	11.0
Fixed carbon, %	63.2	22.2	39.1	79.8
Calorific val., B.t.u./lb.	12,650	5,540	9,750	12,500

* Information from Messrs. *Neyveli Lignite Corporation (Private) Ltd.*

TABLE 3—EXTRACTION OF LIGNITE FROM PALANA DEPOSIT

	Qty (tons)
1940–44 (av.)	44,289
1945–49 (av.)	60,187
1950	20,203
1951	33,076
1952	45,133
1953	34,433
1954	29,615
1955	..
1956	25,615

Lignite tar, obtained as a by-product of low temperature carbonization can be directly hydrogenated under pressure for the manufacture of aviation oil, motor spirit and diesel oil. Synthetic oil can also be obtained by Fischer-Tropsch synthesis based on gasification of lignite char (*Rep. on the Utilization of South Arcot Lignite*, Fuel Res. Inst., Jealgora, 1954, 25).

Lignite may be gasified for the production of semi-water gas and utilized for the production of ammonium sulphate/ammonium nitrate or urea. The *Neyveli Lignite Corporation* (*Private*) *Ltd.*, proposes to gasify about 0.5 million tons of lignite by the total recycle process for the production of 152,000 tons of urea fertilizers.

Other Products—Lignite tar is rich in higher phenols and poly-hydroxy phenols. It can be processed for obtaining chemicals required for plastic and pharmaceutical industries and also for the manufacture of insecticides and disinfectants. The tar contains approximately 7% paraffin wax which can be recovered in purified form. South Arcot lignite contains a small quantity of montan wax which can be extracted with a mixture of benzol and alcohol.

PRODUCTION

Table 3 gives production of lignite from Palana area in recent years. Mining of lignite in the area has been under suspension since 1957. A small quantity of lignite is produced annually in Kashmir; production in the State during 1957, 1958, 1959 and 1960 was respectively 3,733, 6,569, 8,345 and 4,721 metric tons.

Lignum Vitae—*see* **Guaiacum**

LIGULARIA Cass. (*Compositae*)

Fl. Br. Ind., III, 348.

A genus of showy herbaceous perennials distributed in Europe and Asia. About a dozen species occur in India in the Himalayan region; one exotic species is cultivated in gardens.

Several species of *Ligularia* are grown in the open or indoors for their striking flower heads and foliage; they are suitable for potting and also bedding under shade, and are usually propagated by cuttings or division (Bailey, 1947, II, 1858; Bailey & Bailey, 427).

L. tussilaginea (Burm. f.) Makino syn. *L. kaempferi* Sieb. & Zucc.; *Senecio kaempferi* DC. is a low-growing rhizomatous herb with large, orbicular to nearly reniform, dark green leaves; flowering stalk 30–60 cm. long with yellow flower heads. The plant is a native of Japan, and two cultivars, 'Aureomaculata' and 'Argentea', are popular in gardens. The former with golden yellow flecks and blotches on the foliage is grown in Indian gardens. 'Argentea' with silvery-white blotches on the foliage is less commonly grown. The rhizomes of *L. tussilaginea* contain inulin and β-dimethylacrylic acid (Bailey, 1947, II, 1858–59; Lawrence, *Baileya*, 1957, **5**, 98; Firminger, 481; Wehmer, II, 1251).

LIGUSTRUM Linn. (*Oleaceae*)

A genus of shrubs or trees, commonly known as Privets, distributed in temperate and tropical Asia to Australia, with one species occurring in Europe and N. Africa. About 16 species are found in India.

A number of *Ligustrum* species are grown in gardens for their handsome foliage and profusion of white flowers. They are hardy and can be grown in any kind of soil. Propagation is done by cuttings or by divisions and seeds (Krishnamurthi, 217; Bailey, 1947, II, 1859).

L. lucidum Ait. syn. *L. spicatum* Hort. GLOSSY PRIVET, CHINESE PRIVET

Fl. Assam, III, 240.

KHASI—*Soh-pah-iet, dieng-soh-la-paiet.*

A large evergreen shrub or a small tree found in Khasi hills up to an altitude of 1,500 m.; it is often cultivated in gardens. Bark grey with brown coarse strands, corky, dull white inside; leaves ovate or elliptic-lanceolate, coriaceous, glossy; flowers in panicles, creamy white, fragrant; fruit blue black when ripe, oblong, *c.* 1.25 cm. long. A number of horticultural types with variegated leaves are recognized.

The wood is light yellowish brown in colour, even-grained, hard and elastic. It is used for agricultural implements in Assam; it is reported to be used in China for walking sticks, hay forks and umbrella handles (Howard, 496; Fl. Assam, III, 240; Burkill, II, 1343).

L. lucidum is a host of the white wax insect. The berries are reported to be used in Malaya for rheumatism. In China, a decoction of the bark and leaves is taken for promoting perspiration (Burkill, II, 1343; Cheo, *Bot. Bull. Acad. sinica*, 1949, **3**, 136).

L. roxburghii C. B. Clarke

D.E.P., IV, 640; C.P., 1047; Fl. Br. Ind., III, 615.

A small evergreen tree, *c.* 6 m. in height, found on

FIG. 41. LIGUSTRUM ROXBURGHII—FLOWERING BRANCH

the hills in Deccan Peninsula. Bark russet brown; leaves ovate-lanceolate, coriaceous; flowers in panicles, white; fruit curved, 0.75–1.0 cm. long. The plant grows into attractive bushes when raised in deep moist garden soil.

The wood is brownish white and durable: it is locally used for construction purposes and as fuel. The bark is reported to hasten the fermentation of toddy tapped from *Caryota urens*. It contains tannin [Cameron, 181; Edwards *et al.*, *Indian For. Rec.*, *N.S.*, *Chem. & Minor For. Prod.*, 1952, **1**(2), 159].

L. compactum Hook. f. & Thoms. (Assam—*Parseru-thing*) is a glabrous shrub or a small tree, up to 9 m. in height and 0.9 m. in girth, with elliptic-lanceolate leaves and white flowers found in the Himalayas at altitudes of 900–2,700 m. and in North Cachar and Khasi hills in Assam. The plant is grown in gardens and serves as a good bee pasture. The wood is white, moderately hard, close-grained and durable. The leaves are lopped for fodder (Gupta, 312; Singh, *Indian J. Hort.*, 1954, **11**, 52).

L. indicum (Lour.) Merrill syn. *L. nepalense* Wall. (Hindi—*Keri*, *banpatara*; Nepal - *Keri*; Kumaon—*Mercha*) is an evergreen shrub or a small tree with elliptic-oblong leaves and panicles of white flowers found in the temperate Himalayas and Khasi and Jaintia hills up to 1,800 m. The leaves are considered diuretic; they are applied in poultices to bruises. The yellowish wood is reported to be useful for diseases of the teeth (Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37**, 293).

L. japonicum Thunb. (Japanese Privet) is a shrub, up to 3 m. in height, with ovate-oblong leaves and panicles of yellowish white, fragrant flowers cultivated in Indian gardens. The seeds contain reducing sugars (15.5%), mannitol, and a fatty oil (14.9%) consisting of 19.5% saturated (palmitic and stearic) and 80.5% unsaturated acids (mostly oleic: linoleic, 11.5%). A coffee-like drink is prepared from the roasted seeds in China (Crevost & Petelot, loc. cit.: *Chem. Abstr.*, 1953, **47**, 9563).

The leaves contain a glucoside, syringin, mannitol, *p*-hydroxy cinnamic acid, and ursolic acid. Syringin is also present in the bark. Extracts of the leaves show anti-bacterial activity (Wehmer, II, 953; *Chem. Abstr.*, 1951, **45**, 4791; 1952, **46**, 3017; 1955, **49**, 14275; 1950, **44**, 696).

L. perrottetii A. DC. syn. *L. neilgherrense* Wight (Mar.—*Kungin*, *medsing*; Tam.—*Punganchedi*, *koli*; Mal.—*Punnu*; Bombay—*Lokhandi*, *marsingha*) is a large shrub or a small tree, sometimes attaining a height of 6 m., commonly found on the hills of Deccan Peninsula. The wood (wt., 52 lb./cu. ft.) is grey, close-grained, hard, compact and durable. It is locally used for the construction of huts and for fuel (Talbot, II, 198–99).

L. robustum Blume is a large shrub or a tree found in the Himalayas from Kumaon eastwards and in parts of Assam, Bengal, Bihar and Orissa. It is also cultivated in gardens. The leaves and bark contain a bitter principle, tannin and traces of an alkaloid. The wood is cream-coloured and hard. It is a good fuel wood: calorific value: *sapwood*—4,816 cal., 8,670 B.t.u.; *heartwood* 4,801 cal., 8,644 B.t.u. (Wehmer, II, 953; Fl. Assam, III, 239; *Indian For.*, 1948, **74**, 280; Krishna & Ramaswami, *Indian For. Bull.*, *N.S.*, No. 79, 1932, 19).

L. ovalifolium Hassk. is a handsome shrub, native of Japan, cultivated in Indian gardens and prized for hedges. *L. vulgare* Linn., the common European Privet, is also grown in hedges. The leaves and fruits of this plant are medicinal; they are reported to contain toxic principles. The fruits have been used in Germany for colouring wine (U.S.D., 1947, 1506).

Lilac, Persian — *see* **Melia**

LILIUM Linn. (*Liliaceae*)

A large genus of bulbous herbs with unbranched stems, confined mostly to the temperate regions of the northern hemisphere. Popularly known as Lilies, several species are cultivated in gardens for ornament. About a dozen species occur in tropical and temperate Himalayas and in the mountainous regions of S. India; a number of exotics are grown in gardens.

Lilies rank high among bulbous, ornamental garden plants and are esteemed for their stately habit and various coloured flowers. They are mostly hardy perennials requiring for their growth plenty of water all the year round. They thrive well in the cool climate of hill stations; a few species may be induced to grow in the plains, but the bulbs perish in one season. They do well in light, rich, well-drained sandy or loamy soil; soil containing lime should be avoided. Partial shade is necessary. Propagation is by seeds, bulbils, scales and division of offsets. Plants grown vegetatively bear flowers in 2 or 3 years, while those raised from seeds may take as long as 3–4 years, even 5–6 years in some cases. Bulbs of choice species are imported from Holland, England, Burma, China

and Japan (Gopalaswamiengar, 495–96; Bailey, 1947, II, 1863–65; Chittenden, III, 1167; Firminger, 316–17).

Lily flowers are esteemed for their form and fragrance and used for decoration and in religious offerings; they are ideal for cutting. Bulbs and flowers of several species are used as food in China, Japan and elsewhere. Starch is extracted from the bulbs of a few species in China. Medicinal uses are attributed to some of them (Bailey, 1947, II, 1863, 1865; Winton & Winton, II, 191; Porterfield, *Econ. Bot.*, 1951, **5**, 25; Neal, 167).

L. candidum Linn. MADONA LILY, ANNUNCIATION LILY

Bailey, 1947, II, 1869.

A tall smooth herb, 0.6–1.2 m. high, with globular or broadly ovoid bulbs. Leaves oblanceolate or narrow-lanceolate to nearly linear; flowers trumpet-shaped, 7.5–10.0 cm. long, waxy white, delicately fragrant, in close erect raceme. *L. candidum* is perhaps the oldest of the cultivated lilies. It occurs in S. Europe, S.W. Asia, from Corsica to the Caucasus mountains, and N. Persia. It is grown in Indian gardens.

The flowers emit a strong and heavy perfume. Extraction with petroleum ether gave c. 0.22% of a green-brown waxy concrete from which a viscous absolute was obtained in 35% yield. The absolute had the following characteristics: sp. gr.$^{15°}$, 0.9592; $n^{20°}$, 1.4787; acid val., 27.16; ester val., 122.04; and carbonyl val., 18.9. Co-distillation of absolute with diethylene glycol at reduced pressure yielded 8.2% of a volatile oil with the following constants: sp. gr.$^{15°}$, 0.9013; $[\alpha]^{20°}$, +1.47°; $n^{20°}$, 1.4681; acid val., 12.62; and ester val., 96.80. The oil contains acetic, palmitic and cinnamic esters of *p*-cresol, linalool, α-terpineol and a primary phenylethyl alcohol. Absolute of lily may be used with great advantage in high grade perfume compositions of floral as well as oriental type. It is an excellent fixative (Guenther, VI, 73–74).

The bulb is odourless with a somewhat bitter taste. It contains a mucilage and an acrid substance. The bulb is considered demulcent and astringent. A decoction of the bulbs in milk or water is taken for dropsy; a poultice is used as external application for tumours, ulcers and skin inflammations. The fresh flowering plant is used in homeopathy as an antispasmodic; the pollen is used against epilepsy (U.S.D., 1947, 1506; Wren, 233; Steinmetz, II, 274–75).

L. giganteum Wall.

D.E.P., IV, 640; Fl. Br. Ind., VI, 349; Kirt. & Basu, Pl. 976.

JAUNSAR—*Giotra*.

A tall leafy herb, 1.2–3.6 m. high, found in temperate Himalayas from Kumaon and Garhwal to Sikkim, Khasi and Aka hills and Manipur (Assam) at altitudes of 1,200–3,000 m. Bulb oval and broadly ovate; leaves cordate; flowers fragrant, large, funnel-shaped, waxy white with inside of tube purple, outside often shaded green, in terminal racemes. The leaves of the plant are used in external applications for wounds and bruises (Kirt. & Basu, IV, 2521).

L. wallichianum Schult. f.

D.E.P., IV, 640; Fl. Br. Ind., VI, 349; Kirt. & Basu, Pl. 977.

HINDI—*Findora*.

LUSHAI—*Badai*.

A tall slender herb, 1.2–1.8 m. high, found in western Himalayas, Nepal, Lushai hills, Manipur (Assam) and hills of S. India at altitudes of 300–2,400 m. Bulb globular or slightly oval; leaves linear to elliptic-lanceolate; flowers solitary, large, trumpet-shaped, horizontal, creamy white tinged golden yellow at base inside and green outside, sweet-scented. Dried bulb scales possess demulcent properties and are used like salep in pectoral complaints (Kirt. & Basu, IV, 2522).

L. longiflorum Thunb. (EASTER LILY, TRUMPET LILY) is a stout, smooth herb, 0.3–0.9 m. high, native of China, Japan and Formosa and cultivated in many countries, including India, for its flowers which are used as offerings particularly during Easter. Bulb oblate or nearly globular, white or yellow; flowers trumpet-shaped, deliciously fragrant, waxy white, often tinged green near base. A starch of high quality is extracted from the bulbs. The starch (amylose, 34%) contains: moisture, 8.74; ash, 0.37; fat, 0.27; and protein, 0.04%; it resembles potato starch in granule size, gelatinization temperature and X-ray pattern (Bailey, 1947, II, 1865, 1867; Firminger, 316; Gopalaswamiengar, 496; *Chem. Abstr.*, 1944, **38,** 1137; Radley, II, 341, 348).

L. tigrinum Ker-Gawl. (TIGER LILY) is a tall stout herb, 0.6–1.2 m. high, native of China and Japan and cultivated in Indian gardens. Bulb spherical, white or pale yellow; flowers bright salmon red spotted purplish black. The bulbs of the plant are eaten. Analysis of fresh bulbs gave the following values: water, 71.46; protein, 4.51; fat, 0.24; carbohydrate,

21.60 ; crude fibre, 1.04 ; and ash, 1.15% (Bailey, 1947, II, 1870 ; Firminger, 317 ; Gopalaswamiengar, 496 ; Porterfield, *Econ. Bot.*, 1951, **5**, 26).

The bulbs of *L. tigrinum* are considered useful for relieving heart disorders, pain in the cardiac region and angina pectoris ; the effect is slow. The flowers are used for ovarian neuralgia. They strengthen eye-lid muscles and are recommended in myoptic astigmia (Steinmetz, II, 275).

Other species of *Lilium* commonly grown in Indian gardens for their flowers are: *L. auratum* Lindl. (GOLDEN-RAYED LILY) bearing large, deliciously fragrant white flowers with yellow band and numerous red or purple spots ; *L. martagon* Linn. (TURK'S CAP LILY) with claret purple flowers spotted purplish black ; *L. neilgherrense* Wight, found in Nilgiri hills, bearing delicately fragrant flowers with waxy segments of rich buff colour inside, fading to cream, almost white at edge and faintly purple outside ; and *L. regale* Wilson with large, trumpet-shaped white flowers lilac pink outside and canary-yellow deep in the throat [Bailey, 1947, II, 1868, 1870, 1873 ; Firminger, 317 ; Gopalaswamiengar, 496 ; Kohli, *Indian Hort.*, 1958–59, **2**(4), 20].

The bulbs of *L. nepalense* D. Don, found in the Himalayas from Simla to Bhutan, and *L. auratum* are edible. The bulbs of *L. martagon* possess the same medicinal properties as those of *L. tigrinum* (Winton & Winton, II, 191 ; Kitamura in Kihara, I, 93 ; Steinmetz, II, 275).

Lily — *see* **Lilium**

Lily, Blood — *see* **Haemanthus**

Lily, Ginger — *see* **Hedychium**

Lily, Painter's Brush — *see* **Haemanthus**

Lily, Spider — *see* **Hymenocallis**

Lily, Water — *see* **Nymphaea**

Lima Bean — *see* **Phaseolus**

Lime — *see* **Citrus**

Lime, Wild — *see* **Atalantia**

LIMESTONE

Limestone is the general term applied to the variable group of sedimentary deposits whose chief constituent is calcium carbonate. Most limestones are of organic origin and are formed from the debris of the skeletons of animals. During the weathering of rocks by various eroding and corroding agencies, calcium is leached out in the form of soluble salts and the solution seeps into the earth and passes underground or is drained into the sea, later to be deposited as calcium carbonate. Travertine and tufa are sedimentary limestones deposited by evaporation-depositions around springs and streams : stalactites and stalagmites found in caves are formed by a similar process. Soluble lime salts drained into the sea are utilized by corals, *Foraminifera*, molluscs, echinoderms or other marine organisms which build up considerable masses of limestone. Depending on the source organism, limestones may be distinguished as shelly, coralline, crinoidal or nummulitic. Skeletal structures are almost pure calcium carbonate and are frequently found intact in chalk and marl.

Calcareous sediments seldom occur as pure calcium carbonate. More usually they are contaminated with argillaceous, siliceous or ferruginous impurities. Conditions of pressure, temperature and solvent action to which the sediments are subsequently exposed largely influence the degree of consolidation and cementation or subsequent crystallization as carbonate of lime. They are also susceptible to chemical changes. In soft marls and chalks, calcareous particles are loosely cemented ; in marble, consolidation and metamorphosis have proceeded far. Many limestones lie between these two extremes. Exposure to solutions rich in magnesium salts leads to the replacement of calcium by magnesium.

Depending on their physical appearance, limestones are massive when they are crystalline and compact, saccharoidal when granular, lithographic when even-grained and compact, oolitic when composed of minute spherical concretions and pisolitic when the concretions are large, about the size of a pea.

In the pure crystalline form, calcium carbonate occurs as calcite, aragonite and Iceland spar. Crystalline limestone which has been metamorphosed, either dynamically or by contact with igneous intrusions, and capable of taking high polish, is designated as marble.

Limestone containing less than 5% magnesium carbonate is known as high calcium limestone : it is classified as magnesian limestone when the magnesium carbonate content exceeds 5%. Calcareous rocks containing 30–40% magnesium carbonate are known as dolomitic limestone ; those containing more than 40% are classed as dolomite. Table 1 gives the characteristics of different limestones.

TABLE 1—DISTINCTIVE CHARACTERISTICS OF LIMESTONES*

Calcite	Crystalline, rhombohedral; may be of various colours due to impurities; pure transparent variety is Iceland spar
High calcium limestone	Massive deposits laid down as compact beds containing 90–99% calcium carbonate; colour white, yellow, bluish grey, reddish or black; magnesium carbonate, less than 5%
Hydraulic limestone	Impure limestone containing 10–14% of clayey impurities which sets under water after ignition; used extensively in cement manufacture
Kankar	Small nodular lumps composed of calcium carbonate within and a mixture of clay and calcium carbonate outside; occurs within 2–5 ft. from surface in the form of ill defined beds in older alluvium
Chalk	Soft, white or greyish earthy mass, composed of microscopically small remains of *Foraminifera*
Marl	Soft calcareous deposit mixed with clay and sand; often contains fragments of shell or other organic remains; calcareous matter ranges from 20 to 50%
Travertine or Tufa	Deposited in the form of porous blocks near springs or rivers in places where waters carry enough calcium bicarbonate in solution; pale grey or dirty white
Stalactites	Crystalline, transparent to nearly opaque cylinders or cones hanging from roofs of caverns; white to yellowish brown or grey; formed by evaporation of calcium bicarbonated water dripping through roof
Stalagmites	Deposits on floors of caves, usually conical in shape; cones sometimes rise to meet stalactites above

* Kraus *et al.*, 293; Dana, 514; Coggin Brown & Dey, 321.

TABLE 2—PHYSICAL PROPERTIES OF LIMESTONES

	Crushing load (tons/sq. ft.)	Wt./cu. ft. (lb.)
Chalk	72.0–162.1	131.7–166.0
Oolites	90.0–552.6	126.3–156.3
Magnesian limestone	278.0–591.9	132.2–145.4
Carboniferous limestone	806.0	158.0
Sandstone	530.0–861.9	138.6–158.0
Granite	959.9–1,207.7	158.5–161.7

Most limestones are soft enough to be scratched with a knife; their true sp. gr. varies from 2.2 to 2.9. When free from impurities, limestones are white, but they generally contain small quantities of other minerals which affect their colour. Iron oxide imparts red, yellow or brown colour; carbonaceous and bituminous impurities make them bluish grey or black.

The strength, density, porosity and texture of limestones vary considerably, depending upon the impurities and moisture content, even in the same deposit. Massive limestones generally used for building construction possess considerable compressive or crushing strength (1,400–8,300 lb./sq. in.). Table 2 gives the physical properties of different limestones; the corresponding properties of sandstone and granite are given for comparison.

Limestone is almost insoluble in water; it reacts readily, effervescing briskly, with dil. acids. On heating to 800–1,000°, it loses carbon dioxide and is converted to quicklime (CaO); when heated to very high temperatures, it incandesces and glows with an intense white light, a property utilized in certain forms of limelight illumination. High calcium limestone on calcination yields rich or fat lime ($\ngtr$5% foreign matter); impure limestones yield poor or lean lime (10–30% foreign matter). Quicklime swells up in water with the evolution of heat and crumbles to a white powder, known commonly as slacked lime [$Ca(OH)_2$]. Limestones containing clayey matter yield hydraulic limes, i.e. limes which set or harden under water; those containing 15–30% clayey matter produce highly hydraulic limes and limestones with 5–10% clayey content yield feeble hydraulic lime.

Siliceous matter, other than clay, may occur in limestone as sand, quartz and flint, and in combined state, as felspar, mica, talc and serpentine. Small quantities of silica do not affect the utility of limestone for lime production; however, if present in a concentration of 5% or more, silica reacts with calcium oxide to produce fused silicates. For metallurgical and chemical uses, limestone should contain less than 5% alumina and 3% silica.

The presence of iron, sodium and potassium compounds seldom affects the utility of lime for its various applications. Sulphur and phosphorus compounds are, however, objectionable; limestone required for fluxing in iron and steel manufacture should not contain more than 0.05% sulphur and 0.02% phosphorus. Table 3 gives the analysis of some of the important limestones from different areas in India.

Indian limestones belonging to Vindhyans—Kurnools, Bhimas, Palnads and Sullavais, which are all known to be Upper Puranas, contain 70–95% $CaCO_3$ and 1–3% $MgCO_3$ with very little iron (Table 4); the insolubles are usually alumina and silica. They are extensively used in the manufacture of cement. Cuddapah limestones are more magnesian and are unsuitable for cement manufacture.

TABLE 3—COMPOSITION OF INDIAN LIMESTONES*

	Calcite	Chalky limestone Ariyalur)	Marble (Makrana)	Coralline limestone (Saurashtra)	Miliolite limestone (Porbandar)	Tufa (Chunakhan)	Shell (Kottayam)	Flux limestone (Birmitrapur)
CaO	55.60	54.42	55.1	52.95	54.50	54.16	55.40	50.55
Loss on ignition		41.70	..	45.25	42.80	..	44.10	41.43
SiO_2		2.09†	0.98	0.24†	1.51†	1.20	0.03†	3.36
Fe_2O_3	nil	0.43	2.28	0.06	0.22	0.40	0.07	0.91
Al_2O_3		0.55	..	0.12	0.53		0.19	0.64
MgO		0.28	0.58	0.26	0.83	0.87	0.03	2.09
P_2O_5	traces	0.32	..	<0.01	0.06	..	0.03	..
S		0.47	..	0.18	0.07	..	0.05	..

* Bijawat, *Chem. Age, India*, 1957, **8**, 176. † Include acid insolubles.

TABLE 4—ANALYSES OF LIMESTONES FROM DIFFERENT STRATIGRAPHIC HORIZONS

	$CaCO_3$	$MgCO_3$
Vindhyans		
Sullavais	86.4–88.2	0.50 1.01
Bhimas	84.8 88.0	0.50-1.70
Rohtas	84.0	< 3
Palnads	81.0-85.6	0.97 1.05
Takaria (M.P.)	96.16	1.51
Kailaras (M.P.)	84.18	0.82
Shahabad (Bihar)	82.94	3.89
Cuddapahs		
Vempalle	49.58-50.90	29.97 38.45
Pakhals (marble)	55.6 58.2	26.20 39.14
Pakhals (grey)	75.8	21.6
Pakhals (yellow)	78.1	21.2
Pakhals (white)	96.7	2.5
Archaeans		
Khalari (Bihar)	78.54	5.85
Birmitrapur (Orissa)	90.22	4.37
Lanjiberna (Orissa)	89.15	4.31

Archaean limestones have properties similar to Vindhyans.

Distribution

Workable deposits of limestone are widely distributed in India. The occurrences may be considered under four groups, viz. northern (Himalayan), central (Vindhyan), southern central (mainly Cuddapah) and extreme southern (early Pre-Cambrian and also Cretaceous).

The northern (Himalayan) group comprises deposits of widely different ages, from Pre-Cambrian to Tertiary, and extends from Assam to Punjab. These deposits are relatively recent, although they include cores of ancient crystalline marbles. The reserves are vast, but due to their occurrence at high altitudes they are not exploited at present.

The central (Vindhyan) group comprises the most valuable economic deposits. Massive and almost continuous exposures for *c.* 100 miles stretch from Dehri-on-Sone (Bihar) via Rohtas (U.P.) to Rewa (Madhya Pradesh). A large number of the deposits yield limestone rich in silica and therefore unsuitable for metallurgical purposes; they are eminently suited for cement manufacture. South of the Vindhyan group in the eastern region, valuable deposits of Pre-Cambrian age occur in Orissa.

The southern central (Cuddapah) group comprises deposits forming a broken line extending westward across the Peninsula from the east coast to western ghats. The limestones are suitable for cement manufacture. There are few deposits of economic importance in the central part of the Deccan Peninsula.

Occurrences of limestones of Pre-Cambrian and Cretaceous origin are widespread in Madras State and adjoining area: some of the deposits are of very high quality.

ANDHRA PRADESH

Cuddapah & Kurnool districts—The Vempalle limestone of Lower Cuddapah age extends in a wide arc, 1–4 miles wide, for *c.* 175 miles across Cuddapah and Kurnool districts, from near Cuddapah town through Vempalle, Pulivendla and Parnapalle to the neighbourhood of Betamcherla in Kurnool. Much of

the limestone is dolomitic. The Narji limestone follows a straight trend in the north-west direction from a point near Cuddapah, across the two districts, through Banganapalle to Tungabhadra river and beyond.

The reserves of cement grade limestone are practically unlimited; the estimates are: 640 million tons in Kamalapuram taluk, 3,000 million tons in Jammalamadugu taluk (Cuddapah dist.), 5,000 million tons in Koilkuntla, 660 million tons in Banganapalle, 450 million tons in Dhone, 1,250 million tons in Kurnool and 770 million tons in Nandikotkur taluk (Kurnool dist.). Other limestones of younger age than Narji stone also occur in these regions (Coggin Brown & Dey, 331).

Massive high calcium limestone suitable for cement manufacture and, in some cases, for chemical industry, are found south-east of Kurnool town, near Nandyal, Paniam, Betamcherla and other places. Lithographic stone of good quality is available in the Tungabhadra valley in Kurnool and in Nandyal taluk. Large deposits of tufaceous limestone occurs near Nandavaram, Palkur and Dronachalam in Kurnool dist. *Kankar* deposits are widespread and are worked for local use at several places (Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 178).

Krishna & Guntur districts–Limestone deposits occur extensively on both sides of Krishna river in the Palnad region of Guntur and in Jaggayapeta–Mutyala area of Krishna dist. The river between Amaravati and Warapilli flows largely through limestone. The deposits include light to dark grey flags and building and ornamental stones of various colours. Limestone of greenish colour is found near Pulichinta on the right bank of the river; the deposit extends towards Cuchillabode where it becomes flaggy. The reserves of cement grade limestone near Jaggayapeta have been estimated at 269 million tons. Fairly large deposits are also found near Piduguralla (on Guntur Macherla branch line). Lithographic limestone occurs in Jaggayapeta area near Kondapilli (16°37′:80°33′) and Betavole (16°53′30″:80°6′), and also near Chintapalle (16°42′:80°9′) on Krishna river.

Large deposits of compact, sub-crystalline, fine-grained limestone of variegated colour resembling marble are found in the Palnad tract covering Nadikudi, Rentichintala, Dachepalle, Kesanapalle, Uddalur, Sitaramapuram and parts of Macherla sub-taluk; the reserves in two deposits in Macherla sub-taluk alone are estimated at 124 million tons. Good lithographic limestone is also found near Dachepalle. *Kankar* is widely distributed in Guntur dist. particularly in the black cotton soil tracts (Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 176; *Indian Ceram.*, 1956–57, **3**, 372: Bijawat & Sastry, 60).

Other districts–Vempalle and Jammalamadugu limestones are found in Tadpatri and Gooty taluks of Anantapur dist. In the former taluk, high grade limestone occurs below hill scarps north and east of Kona Rameswaraswami temple, 10 miles from Rayalacheruvu railway station. Also, calcareous shales and intercalated limestones of the Cheyair group have given rise to *kankar* and tufa, with lime averaging 38.85%, and magnesia, 8.46% (Bijawat & Sastry, 55–56: Coggin Brown & Dey, 332).

The Kurnool limestone, as well as the limestone underlying Cuddapah system cross over from Kurnool dist. to Alampur taluk of Raichur dist., whence they extend for 150 miles along the north bank of Krishna river; Cuddapah exposures continue to the east. Limestone occurs also in Wazirabad–Medlacheruvu region of Nalgonda dist. (Coggin Brown & Dey, 332).

Limestone occurs in Asifabad and Karimnagar districts of the former Hyderabad state. In Asifabad dist., deposits have been located at Mankigudem, Rali forest and near Empally village in Sirpur taluk. The lime produced in this area is used for causticization in paper mills and also for other purposes. In Karimnagar dist., high grade limestone occurs in Narella and Putnur. West of Hyderabad town, the Bhima limestones emerge from below the Deccan Trap in the Bhima and Kanga river valleys. Limestone of Bhima series is an important source of chemical and building lime; it analyses to: CaO, 48.2–50.0; CO_2, 37.64–37.68; SiO_2 and acid insolubles, 10.30–10.47; loss on ignition, 38.85–39.05; available lime at 900°, 62.54–68.89% (Bijawat & Sastry, 50, 54).

Limestone occurs also in Adilabad, Visakhapatnam, Jeypore, and in East and West Godavari districts.

ASSAM

Nummulitic limestone occurs as discontinuous bands varying from 20 ft. to 700 ft. in thickness along the southern wall of Garo, Khasi, Jaintia and Mikir hills. The limestone in Shillong plateau forms the well known Sylhet limestone stage of the Jaintia series and overlies the coal-bearing strata; it is of cement and flux grade. Limestone from Khasi hills contains 53.86–54.28% calcium oxide; that from

Garo hills 50.30%. Limestone also occurs at Cherrapunji and in North Cachar hills [Dutt, *Indian Min. J.*, 1957, **5** (10), 32; Bijawat, *Chem. Age, India*, 1957, **8**, 176].

In Garo hills, prominent exposures of limestone of 50–300 ft. thickness occur in the southern part of Tura range. The deposits await detailed investigation. In the Khasi hill section, the limestone extends from Lamgaon (25°10′:91°51′) westwards through Therriaghat to Sheela river. The total thickness of the limestone in this area is over 1,000 ft. The reserves between Therriaghat and Sheela river are estimated at 1,000 million tons of high grade limestone. Therriaghat limestone contains: CaO, 54.28 and SiO_2, 0.57%. Limestone occurs also west of Sheela river in the Nawswayram and Lumgrim (25°11′:91°07′) areas. In Jowai sub-division of the Khasi-Jaintia hill dist. good quality limestone (CaO, 51; MgO, 1; insolubles, 3%) has been recorded at Lumshong (92°23′:25°10′), Garampani (92°37′:25°31′), Nongklih (92°32′:25°20′), Syndai (92°9′:25°11′) and a few other places. The reserves in this subdivision are of the order of 25 million tons. Limestone of good quality occurs in the northern part of Mikir hills bordering Nowgong and Sibsagar districts between latitudes 25°45′ and 26°5′ and longitudes 93°10′ and 93°40′. The reserves in this area are reported to be 154 million tons [Nath, *Indian Miner.*, 1959, **13**, 310; Bijawat, *Chem. Age, India*, 1957, **8**, 176; Dutt, *Indian Min. J.*, 1957, **5**, (10), 32].

BIHAR

Bihar is the largest limestone producing State in India. The most important deposits occur among Vindhyan formations in Shahabad dist. They are traceable for about 45 miles in Bihar and extend westward into Uttar Pradesh along the slopes of Kaimur hills. Prominent outcrops of limestone are near Banjari (24°41′:84°0′), Rohtas (24°39′:83°59′), Kaoriari (24°41′:83°54′), Baulia (24°16′:83°54′), Baraicha (24°39′:83°52′), Chunhatta (24°36′:83°52′), Ramdhira-on-Sone (24°46′:84°2′), Dhanauti (24°36′:83°51′), Birki (24°31′:83°40′) and Domarkhoka (24°32′:83°31′). Of these, the deposits in the Banjari–Rohtas, Baulia–Chunhatta–Dhanauti and Birki–Chapla areas are of high grade and also contain flux grade limestone. The first two areas are being exploited at present to feed the cement factories [Jacob & Mahadevan, *Indian Min. J.*, 1957, **5**(10), 53; Nath, *Indian Miner.*, 1959, **13**, 306].

In Palamau dist., extensive deposits of limestone occur in isolated patches over a zone extending nearly east-west, from near Ramgarh to Khalari and near Daltonganj. Important among the deposits are those near Bakoria (20 miles off Daltonganj) and Banpahar (23°59′:83°59′), Harhipahar (23°56′:83°57′) and Chauparia (23°58′:83°57′) where the limestone forms a group of small hills. Good quality flux grade limestone, belonging to the Kajrahat stage of the Vindhyan system, has been reported at Chapri (20°24′:83°34′) and Bajetoli (24°24′:86°36′30″) about 35 miles from the Garwa Road railway station (Nath, *Indian Miner.*, 1959, **13**, 306).

Limestone of the Kolhan series occurs over a belt of *c.* 30 miles extending from Chaibasa (22°33′:85°48′) to Jagannathpur (22°12′:85°39′) in Singhbhum dist. The calcium oxide content of Kolhan limestone averages 50.58%. Limestone also occurs in the deposits at Putada springs (north of Chaibasa), Lota Pahar (22°37′:85°34′), Ghatkuri (22°18′:85°24′) and Patang (22°23′:85°24′) (Khedker, 139).

In Hazaribagh dist., a limestone zone striking east-west occurs in Bundu–Basaria area (23°40′:85°23′ 85°26′) in Ramgarh estate. The reserves of crystalline limestone of cement grade in the area are estimated at 3 million tons. In the same region, two more zones are reported, one in Kurkuta–Religara (23°43′:85°21′–85°22′), and the other in Lapanga–Bhurkunda–Kursa (23°38′:85°21′); the reserves in the former zone are reported to be large. Limestone of good quality occurs also in the Hosir-Bachra-Dundu–Ray (23°40′:85°3′–85°7′) region (*Indian east. Engr*, 1953, **112**, 569; Khedker, 141).

A crystalline limestone band covering a distance of *c.* 3½ miles with an average width of 250 ft. occurs near Purna Ray (23°40′:85°3′) partly in Ranchi dist. and partly in Hazaribagh dist. Samples from the band analysed to CaO, 45.85–50.34% and MgO, 5.05–8.12%. In Ranchi dist., a limestone zone occurs with an east west strike in Babhane–Hoyar–Khalari (23°38′–23°40′:85°00′ 85°04′) region; towards the Khalari end, limestone is quarried in Bagda, Salhan and Benti villages for supplying cement factories; the lime content of the deposits averages 45.60% (Banerjee, *Quart. J. geol. Soc. India*, 1956, **28**, 149).

GUJARAT

In Banaskantha dist., crystalline limestone occurs in considerable quantities near Khunia (24°22′30″:72°41′), Pasuval (24°28′:72°22′), Diwania (24°22′:72°41′) and Karamudi (24°22′:72°46′). The reserves

at Pasuval and Diwania are estimated at 8–9 million tons within a depth of 100 ft. The limestone is suitable for use in cement, chemical and metallurgical industries (Roy, *Indian Miner.*, 1956, **10**, 103).

In Broach dist., large deposits of massive limestone of variable composition occur near Vanji (21°54′: 73°48′), Gora (21°52′: 73°41′), Bhilod (21°36′: 73°12′), Bharan (21°30′: 73°2′) and several other localities. In Kaira dist., a limestone bearing strip, *c.* 16 miles long and 2 miles wide, occurs near Balasinor (22°58′: 73°20′): the reserves are estimated at 800 million tons: *c.* 200 million tons are of cement quality.

Limestone also occurs in Baroda, Sabarkantha, Dang and Surat districts.

Calcareous marine formations are found along the Kathiawar coast from Dwarka to Veraval in the south and Malia in the north. The best known deposit is in the vicinity of Ranawao in Porbandar dist. The limestone ($CaCO_3$, *c.* 96%) is composed chiefly of the testa of *Foraminifera* cemented by calcite. It is quarried at Aditania (21°43′: 69°44′), Bharwada and Bakharla for use in building, chemical and cement industries.

Extensive deposits of miliolite limestone occur in Gondal dist. and are quarried around Jat, Patanwao, Zinjuda, Upleta and Paneli. The chips are used in chemical works at Kharaghoda, Dhrangadhra, Ahmedabad and other places.

In Amreli dist., high calcium miliolite limestone occurs in the coastal area around Kodinar and Okhamandal. The limestone from Adivi, Dholasa and Harmaria in Kodinar area contains, on an average, 93% calcium carbonate. Coralline deposits are found along the coastal margin of Okhamandal. They are being utilized by *Tata Chemicals Ltd.*, Mithapur.

In Junagadh dist., miliolite limestone occurs around Veraval (20°54′: 70°25′), Patan (20°53′: 70°27′), Gorakhmudi (20°54′20″: 70°34′40″), Prachi (20°55′20″: 70°39′) and many other places. The deposit in Gorakhmudi is *c.* 1 mile long and 2 furlongs wide. Pure limestone ($CaCO_3$, 96–97%), suitable for chemical purposes, is found in the coastal area around Veraval (Roy, 1953, 162).

In Gohilwad dist., extensive deposits of miliolite limestone of cement quality occur near Jafrabad (20°52′: 71°22′) within the limits of Babarkot (20°52′: 71°24′), Bhakodar (20°54′: 72°27′) and Vand (20°54′: 71°25′) to the east of Jafrabad, and between Jafrabad and Balana (20°51′: 71°17′) on the south-west: the total reserves in both areas amount to 64 million tons.

In the former Navanagar state, miliolite limestone occurs in numerous localities. The limestone from Gop area is used by the *Digvijay Cement Works Ltd.*, Sika, for the manufacture of cement. Occurrences have also been reported in the former Bhavnagar, Morvi and Limbdi states.

In western Kutch, Tertiary limestone deposits cover an area of *c.* 150 sq. miles (latitude 23°20′–23°45′: longitude 68°32′–69°0′). The limestone occurs as massive outcrops, the thickness of beds varying from 65 to 310 ft. Much of the mineral is suitable for cement manufacture. Reserves have not yet been assessed [Poddar, *Rec. geol. Surv. India*, 1958, **88** (1), 121].

HIMACHAL PRADESH

In Sirmur dist., extensive deposits of limestone are found in Lower Giri valley. Fine-grained light grey limestone of cement grade (CaO, 49.51%) occurs near Sataun (30°34′: 77°38′30″) between Bhatrog (30°33′: 77°40′) and Kyari (30°34′: 77°34′30″); the reserves in these deposits are estimated at 141 million tons. In the same area, siliceous limestone occurs along the path from Sataun to Poka; white crystalline limestone occurs at Naura (30°49′: 77°25′30″), Bhangari (30°47′: 77°24′30″) and Jarag (30°50′: 77°21′30″). Limestone zones have also been located near Barthal (30°33′: 77°26′), Tina (30°33′: 77°24′), Kansar (30°33′: 77°29′), Khair (30°34′: 77°31′) and Bakan (30°34′: 77°32′). In the Kansar area, the reserves of cement grade material are estimated at 17 million tons up to a depth of 300 ft. [Nath, *Rec. geol. Surv. India*, 1950, **83** (1), 140; Dutt, ibid., 1954, **85** (1), 70].

In Mandi dist., fairly extensive occurrences of dolomitic limestone are found underlying the salt bed. Chemical grade limestone (CaO, 52.62%) occurs near Malan above Harabagh (Dubey *et al.*, *Quart. J. geol. Soc. India*, 1949, **21**, 43).

In Mahasu dist., limestone of cement quality occurs at Khadli and Kakkarhatti [Raina, *Rec. geol. Surv. India*, 1954, **85** (1), 70].

JAMMU & KASHMIR

Large limestone deposits are found in Jammu & Kashmir in practically every geological formation. The Pre-Cambrian Salkhalas contain crystalline limestone generally dolomitic. Lenticular limestone bands are seen in Cambrian and Ordovician; and yellowish impure bands in the Silurian; limestone beds also occur in the Zewan series, Upper Trias and Eocene. The Great Limestone of the Riāsi area in Jammu province is mostly dolomitic.

Triassic limestones are the most important from the point of view of distribution, extent and quality. The lime (CaO) content of most of them varies between 43 and 52%; the magnesia (MgO) content is below 2%. In Anantnag dist., reserves of 34 million tons have been proved in the Verinag–Zamalgam Tserkar–Doru–Naupura belt. Massive deposits have been located near Acchibal and Bawan in the same district and near Bandipura, Ajas, Gund-i-Sudarkut, Biru and Sonamarg Zoji La in Baramula dist. Sizable occurrences have also been found in Vihi valley [Mehta, *Indian Min. J.*, 1957, **5**(10), 61].

KERALA

Shells (CaO, 54.5–55.4%) constitute the most important source of high grade lime in the State; they are found in Vembunad lake area, between Kottayam and Alleppey. The reserves are estimated at 2 million tons (Bijawat & Sastry, 67 : Macedo, 49).

MADHYA PRADESH

Limestone deposits in Madhya Pradesh are extensive. The Vindhyan limestone forms a band running from Jabalpur to Satna; Cuddapah limestone occurs in Raipur–Bilaspur area.

In Jabalpur dist., extensive deposits of limestone are found in Katni-Murwara and Jukehi–Kymore areas, the more important among them are located at Murwara (23°50′:80°24′), Tikaria (23°49′:80°23′), Bistara (23°58′:80°28′), Bargama (23°50′:80°23′), Amehta (24°0′:80°35′), Khandra (23°35′:80°7′), Jukehi (23°59′:80°26′) and Kymore (24°3′:80°39′). The limestone of Bistara and Amehta is suitable for calcium carbide manufacture. Large deposits of marble of good quality occur as hills near Jabalpur; they are collectively designated as the 'Marble Rocks' [Dutt & Chatterji, *Rec. geol. Surv. India*, 1954, **84** (3), 367].

The Vindhyan limestone in the Katni–Satna area is extensive; it is over 100 miles long, many miles wide in certain areas, and 25-40 ft. deep. The quality varies from high calcium limestone in the direction of Jabalpur to high siliceous stone (Si, 8–15%) in the area around Satna (Macedo, 58).

In Raipur and Drug districts, extensive deposits of massive and flaggy limestone occur in discontinuous patches between Barondha (21°5′:82°3′) and Sukhri (21°1′:80°54′), over a distance of about 80 miles. The limestone is low in magnesia. In Raipur dist., quarries are located *c.* 2 miles from Raipur town on the Kahadeoghat road, just east-north-east of Khushalpur village (21°13′:81°37′), Telibandha area, and near Birgaon (21°18′:81°38′). The estimated reserves in Raipur dist. are 17.2 million tons. In Drug dist., flux grade limestone occurs at Meresera, Deorjhal, Bhanpuri, Nandgaon and Nandini regions. The reserves of flux grade limestone in Meresera and Deorjhal are estimated at 20 million tons and 65 million tons respectively. In Nandgaon, limestone band stretches for *c.* 30 miles between Khalawa and Arjuni. Extensive deposits of flux grade limestone occur at Nandini, about 16 miles from Bhilai [Chatterjee, *Rec. geol. Surv. India*, 1953, **84**(1), 87; Dutt, ibid., 1954, **84**(3), 392; *Res. & Ind.*, 1960, **5**, 188; Indian Minerals Yearb., 1959, 206].

Extensive deposits of limestone suitable for use in metallurgical and chemical industries occur in Bilaspur dist. The major occurrences are found around Gobripat (22°17′:81°59′), Maharpur (22°15′: 81°42′), Bankat Nawagaon (22°15′:81°43′), Paraswara (22°13′:81°50′), Belpan (22°12′:81°52′), Limha (22°13′:81°50′), Bijaipur (22°13′:81°48′), and a few other localities. Discontinuous patches of cement grade limestone are found in a zone beginning from near Birgahani (22°1′:82°38′) and Darrabhata (22°2′:82°37′) on the western bank of Hasdo river right up to Akaltara (22°1′:82°25′) and Latia (22°1′:82°24′). Flux grade limestone occurs over an area of 6 furlongs square near Mohtara (22°0′: 82°17′); the reserves are estimated at 10 million tons [Sinha, *Rec. geol. Surv. India*, 1954, **86**(1), 107; Chatterjee, ibid., 1950, **83**(1), 141].

In the former Madhya Bharat region, a band of siliceous limestone (Lower Bhander) occurs for a distance of *c.* 80 miles across Morena, Shivpuri and Guna districts. Between Kailaras (26°19′:77°40′) and Palpur (25°48′:77°12′) the limestone band runs for *c.* 30 miles in approximately NE SW direction. Flaggy limestone of good quality occurs between Kailaras and Bakaspoora (26°15′:77°31′) and also between Jwahirgarh (26°9′:77°20′) and Garhi (26°7′:77°21′) (Roy Chowdhury, *Bull. geol. Surv. India, Ser. A*, No. 10, 1955, 44).

In the Narmada valley area, extensive deposits of dolomitic limestone of the Bijawar formation occur near Burwaha (22°15′:76°2′) and Barjar (22°22′: 76°2′). The reserves within a radius of a few miles from Burwaha are estimated at 215 million tons. Large deposits have also been recorded around Dharampur Pathra, Dhimarwan (24°26′:79°20′) and Amronia [Roy Chowdhury, loc. cit.; Chatterjee, *Rec. geol. Surv. India*, 1953, **79**(1), 322].

In Gird dist., exposures of cherty and siliceous limestone occur near Choura (26°06′:78°10′), Naigaon (26°7′:78°7′), Morar (26°14′:78°13′), Old Residency, Gwalior (26°16′:78°11′) and a few other places.

In Mandasor dist., large exposures of Nimbahera limestone occur near Jawad (24°36′:74°52′), Nimbahera (24°37′:74°42′) and a few other places. The total thickness of the Nimbahera bed is *c.* 450 ft.; reserves are reported to be practically inexhaustible. Limestone is quarried near Subakhera (24°32′:74°52′), Khera (24°34′:74°49′), Kandkha (24°32′:74°48′) and Bisalwas (24°31′:74°48′) for building purposes.

In Jhabua and Dhar districts, nodular, coralline and lameta limestones are found in the Man valley near Balwari and south and west of Bag. Extensive deposits of high grade Cretaceous limestone suitable for electro-chemical and cement industries also occur in the region.

Travertine limestone deposits of high purity ($CaCO_3$, 94–99%) occur in several localities in Indore, Shivpuri and Gird districts (Roy Chowdhury, *Bull. geol. Surv. India, Ser. A*, No. 10, 1955, 53).

In the Satna area, 3 bands of Lower Bhander limestone occur, with calcareous flagstone on top. The band which yields the best material is found up to a depth of 30 ft. in two well-defined sections, one at Satna (23°33′:80°53′) and the other at Maihar (24°17′:80°47′). Limestone quarries in the Satna area lie roughly along a line due E.NE–W.SW and extend from 24°38′:80°54′ to 24°35′: 80°47′, the end workings being *c.* 7½ miles apart. This patch forms only a part of the large limestone area mapped in this region. The Maihar group of quarries lies along a line 1½ miles long in approximately NE–SW direction. The Satna deposit is over 200 sq. miles in area, and reserves are estimated at 12 million tons per sq. mile [Fox, 43; Bijawat & Sastry, 28; *Rec. geol. Surv. India*, 1950, **83**(1), 149].

Limestone deposits are also found in Bhopal, Chanda, Hoshangabad and Betul districts.

MADRAS

In Tirunelveli dist., crystalline limestone is found in 14 bands, of which three occur near Ramayyanpatti (8°45′:77°41′), 5½ miles from Tirunelveli town. The total reserves in the district have been conservatively estimated at 0.45 million tons, of which the Ramayyanpatti bands account for 0.25 million tons (Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 191).

In Ramanathapuram and Madurai districts, three rich limestone bands occur within 10 miles of each other at Pandalkudi (9°23′:78°0′), Palavanattam (9°33′:78°0′30″) and Chinnayapuram (9°28′30″: 70°54′15″). These deposits are reported to contain, 2.1 million tons of high grade limestone and 4.2 million tons of poorer material within a depth of 20 ft. Several bands of crystalline limestone are found near Tirumal (9°43′:78°3′) also. Two bands of limestone, one near Sunnambur (9°52′30″:78°17′30″) and the other near Puvandi (9°51′:78°18′) contain one million tons of good quality limestone. Limestone deposits also occur in Sattur and Aruppukottai taluks; the reserves are estimated at 4.4 million tons (Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 189; *Res. & Ind.*, 1959, **4,** 212).

Coral limestone occurs along the Ramanathapuram and Tirunelveli coast for a distance of 80–90 miles, extending for a few miles along the sea bottom. There are also more than 20 islands within 4–5 miles from the coast in the Gulf of Mannar from which coral limestone (CaO, 52%) is quarried. A deposit of shelly limestone occurs *c.* ½ mile north of Rameswaram (9°17′:79°19′); the reserves are estimated at 80 thousand tons. Coral limestone reserves in Rameswaram Island have been assessed at 5 million tons [*Res. & Ind.*, 1959, **4,** 212; Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 196; Bijawat & Sastry, 65; *Rec. geol. Surv. India*, 1954, **86**(1), 106].

In Tiruchirapalli dist., large deposits of massive limestone occur in Lalgudi and Perambalur taluks. Nodules of chalky limestone are found near Karai (11°8′:78°53′) and a few other localities in an area of 5–6 sq. miles. Shelly limestone occurs at Garudamangalam (11°5′:78°55′) and a few other localities. The reserves of chalky limestone and chalky clay within a depth of 10 ft. have been estimated at 1.5 million tons. Three major bands of crystalline limestone occur near Tarakkampatti (10°42′30″: 78°14′30″), Allinagaram (10°45′30″:78°18′) and Kiranur (10°47′:78°17′) in Kadavur Zamindari in Kulittalai taluk; of the total estimated reserves of 544 thousand tons in these three bands within 10 ft. depth, more than half is said to be of high calcium grade (Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 182).

In Salem dist., about 30 bands of crystalline limestone occur in Tiruchengode and Namakkal taluks. The largest of these is the Puduppalaiam (11°25′: 77°47′30″)–Pulappalaiam (11°27′:77°47′30″) band containing *c.* 176 thousand tons of limestone. White, grey and pink coloured calcite occurs near Sankaridrug (11°28′30″:77°52′) in Tiruchengode taluk. The

total reserves in these taluks are estimated at 741 thousand tons within a depth of 10 ft. (Krishnan, *Mem. geol. Surv. India,* 1951, **80,** 184; Bijawat & Sastry, 69).

In Coimbatore dist., extensive beds of crystalline limestone occur in the hills near Madukkarai (10°54′: 76°57′). In South Arcot dist., beds of shelly limestone and argillaceous massive limestone are found near Sedarampattu (11°59′: 79°45′) and a few other places. The total reserves in South Arcot dist. are estimated at 2 million tons. In Tanjore dist., limestone occurs south of Alakkudi railway station (10°47′: 79°4′) and in some other localities (Krishnan, *Mem. geol. Surv. India,* 1951, **80,** 188, 182).

MANIPUR

Fine-grained and somewhat brittle limestone occurs in pockets in Ukhrul area near Lambui (94°17′: 25°1′), Hungdung (94°2′30″: 25°4′), Shuganu (93°53′: 24°17′30″) and in some other places. The reserves in the area are estimated at 2.7 million tons of which 2 million tons of high calcium limestone (CaO, 52.98%) are available near Hungdung and 0.5 million tons near Lambui (CaO, 45.54%) [Banerjee, *Rec. geol. Surv. India,* 1949, **82**(1), 61].

MYSORE

In Bijapur dist., large limestone deposits of Bhima series suitable for cement and chemical industries occur between Bagalkot (16°11′: 75°45′) and Kaladgi (16°21′: 75°30′), covering an area of *c.* 30 sq. miles. The estimated reserves in Bagalkot taluk are 800 million tons up to a depth of 15 ft. Another limestone deposit (CaO, 43.80–50.42%), partly lithographic, covers an area of *c.* 10 sq. miles near Talikota (16°28′: 76°18′); the reserves have been estimated at 300 million tons. Extensive deposits of high calcium limestone occur in Mudhol taluk in a band running from Lokapur (16°9′: 75°22′) to Petlur (16°14′: 75°19′) and thence to Mallapur (16°9′: 75°19′). The reserves are estimated at several million tons [Mukerjee, *Rec. geol. Surv. India,* 1955, **79**(2), 807: Roy, 1951, 90].

In Gulbarga dist., limestone occurs near Maralbhavi, Backenhalli and Shahabad. The Shahabad limestone is grey in colour (Bijawat & Sastry, 50).

In Belgaum dist., high calcium limestone occurs near Yadwad (16°14′: 75°11′) and Manami (16°11′: 75°11′) [Roy, *Rec. geol. Surv. India,* 1950, **85**(3), 309].

In Tumkur dist., extensive limestone occurrences are known at Kondli, Voblapur, Dodguni and Vajra. In Chitaldrug dist., limestone deposits are found near Hosdurga. In Shimoga dist., flux grade limestone is found near Bhadigund, 13 miles east of Bhadravati. These areas contain about 50 million tons of limestone, averaging CaO, 49; SiO_2, 3 4; and MgO, 2.8% (Coggin Brown & Dey, 335).

ORISSA

In Sundargarh dist., flux grade limestone bands occur near Birmitrapur (22°24′: 84°44′); the bands extending over a length of 4 miles and a width of 700–800 ft. cover both low plains and a group of hills; the deposits, belonging to the Archaean age, are associated with other calcareous and phyllitic rock. The reserves in Birmitrapur area up to a height of 100 ft. in the hills and 100 ft. below, have been estimated at 274.6 million tons of which roughly 10% is of metallurgical grade.

In Khatma Nala valley, a band of good quality limestone runs from one mile west of Hathibari (22°24′: 84°51′) to Deo river; the band widens considerably towards the east of Gatitangar (22°24′: 84°54′). In Hathibari area, the hill north of Bajnathpur (22°24′: 85°57′) contains at least 1.5 million tons of flux grade limestone within a depth of 100 ft. Limestone of good quality occurs in the northern part of the band in Purnapani (22°25′: 84°52′) area; the reserves of flux grade limestone, up to a depth of 100 ft., are estimated at 9.48 million tons. In the Gatitangar area, exposures are found over a wide area on the southern side of Tikamtoli (22°25′: 84°54′) and north and east of Kijurtoli (22°24′: 84°54′); workable reserves up to a depth of 100 ft. have been estimated at 3.04 million tons of flux and cement grade mineral and 2.47 million tons of material suitable for use in blends with fluxing limestone. The occurrence at Lanjiberna (22°15′: 84°30′) carries, up to 100 ft. depth, about 16 million tons of cement and flux grade material in the southern and northern parts of the deposit; the reserves of flux grade limestone in the northern part has been estimated at 4 million tons. The central part is not so payable. At Ludhkutoli (22°15′: 84°25′), limestone occurs mostly under alluvium and *c.* 2 million tons of good material are reported to be available within a depth of 60 ft. Cement grade limestone occurs near Khatkurbahal (22°17′: 84°29′) and Amghat (22°15′: 84°37′). Flux grade and probably cement quality limestone is available *c.* ½ mile north of Katang (22°14′: 84°29′). Limestone also occurs at Dublabera, Saromohan, Kandaimunda, Kukurbhuka, Usra, Barpali and other places (Narayanaswamy *et al., Bull. geol. Surv.*

India, Ser. A, No. 12, 1957; Nath, *Indian Miner.*, 1959, **13**, 301).

In Sambalpur dist., extensive deposits of coloured limestone occur with intercalations of shales in an area of 8 sq. miles around Dungri (21°42′:83°34′), Sauntmal (21°41′:83°33′), Badmal (21°40′:83°33′), Behera (21°39′:83°32′), Kusumda (21°37′:83°30′) and Banjipali (21°38′:83°30′). The reserves in this area are estimated at several hundred million tons. Typical bands at Dungri, Badmal and Banjipali contain limestone with more than 48% CaO. Five million tons of dolomitic limestone, of which perhaps one-third would be of good quality, are available north of Sulai (21°58′:84°06′). Limestone also occurs with shales near Padampur, Lakhanpur and Putka (Economic Geology of Orissa, 85).

In the Koraput dist., flux grade limestone occurs about 3 miles west of Kottametta (18°20′:81°42′) near Sabarai river. The deposit extends about one mile along the river bank and analyses 53.36% CaO. Argillaceous limestone occurs south of Nandivada (18°19′:81°40′) and along the Kolab river near Guptesvara (18°49′:82°10′) and Sirivada (18°50′:82°10′). Stalactites and stalagmites are found in the cave temple of Guptesvara. Deposits containing limestone and marble also occur around Nandivada; the reserves up to a depth of 15 ft. are estimated at 15 million tons (Economic Geology of Orissa, 83-84).

Cement and chemical grade limestones are reported to occur over an area of 10 sq. miles between Umpavalli and Tunmiguda; the reserves of high grade material up to a depth of 30 ft. are 40 million tons.

PUNJAB

In Ambala dist., deposits of limestone occur 10 miles east of Chandigarh at Tundapathar (30°45′:77°0′), Kharag (30°43′:77°5′) and in Ramsar–Sherla (30°40′:77°5′-30°40′10″:77°7′) area. Tundapathar limestone contains 92-93% $CaCO_3$ (av.). The reserves have been estimated at 25 million tons. Detailed proving operations have recently been taken up in the region by the Indian Bureau of Mines. Near Junpur (30°45′:77°1′) occurs a massive limestone band traceable for *c.* 3 miles: a specimen from the area analysed 53.54% CaO. A deposit north of Dabsu (30°38′:77°9′) carries, up to 300 ft. depth, a reserve of *c.* 1.7 million tons of limestone suitable for cement manufacture. High grade limestone also occurs near Basharat (32°47′:73°6′) and Chhidru (32°33′:71°46′). Deposits are also found at Barun, Mataur, Ambri, Sirmara, Barach and Bonulu. About one million tons of concretionary limestone is reported to be available near Mataur [Sahni & Iyengar, *Rec. geol. Surv. India*, 1950, **83**(1), 146; Indian Minerals Yearb., 1959, 206; Dey, *J. sci. industr. Res.*, 1946, **5**, 18; Dutt, *Rec. geol. Surv. India*, 1953, **84**(1), 95].

In the former Patiala state, limestone of good quality occurs near Malla (30°46′:77°0′). In Narnaul (28°3′:76°6′), a more or less continuous band of limestone, extending to a distance of 7 miles, occurs between Dhani Bathunta (27°59′30″:76°7′) and Kalika-Nangal (27°55′:76°7′) under alluvium and blown sand; outcrops are seen also near Bahmanwas (27°52′:76°9′), Binhari (27°51′:76°9′) and Baliari. Moderately large deposits of calcite of optical quality are found in some of the hills to the north-west and west of Narnaul town [Bijawat, *Chem. Age, India*, 1957, **8**, 181; Srivastava, *Rec. geol. Surv. India*, 1954, **85**(1), 70; Bose, ibid., 1906, **33**(1), 59; Chhibber & Singh, *J. sci. industr. Res.*, 1946, **5B**, 23].

In Gurdaspur dist., limestone occurs extensively as boulders and pebbles in the bed of Chakki river. In Kangra dist., limestone is found near the Dundiara rest house, near Dharmkot close to Dharmsala and at Bhated Khad. In Simla dist., krol limestone occurs near Barog.

RAJASTHAN

In Ajmer-Merwara, extensive deposits of pure and homogeneous dolomitic marble are found between Kesarpura (26°19′:74°33′) and Saradhana (26°27′:74°34′); the reserves in this region are estimated at over 25 million tons. Large deposits of siliceous and dolomitic limestones occur in several localities: the Gangwana (26°32′:74°43′) deposit of siliceous limestone carries reserves of 1.5 million tons, the reserves of banded white dolomitic marble at Akhari are estimated at 4 million tons. Other limestone and marble bearing localities are: Beawar (26°9′:74°17′), Sawar (25°45′:75°13′), Odas (26°18′:74°19′), Sheopura (26°16′:74°21′), Makhupura (26°24′:74°40′) and Sulia Dungar (26°23′30″:72°42′) (Roy, *Mem. geol. Surv. India*, 1959, **86**, 210).

In Alwar dist., dolomitic limestone occurs at Bund Bagola near Rajgarh; a sample analysed to 42.64% CaO and 3.74% MgO. A variety of tufaceous limestone of exceptional purity (reserves, *c.* 250 thousand tons) is found near Ghatra.

In Banswara dist., limestone and marble occur between Khamera (23°47′:74°30′) and Bhongra

(23°41′ : 74°33′) in an area of 4 sq. miles ; an average sample contained 51.64% CaO. The reserves in the area have been estimated at 50 million tons within a depth of 15 ft. (Roy, *Mem. geol. Surv. India*, 1959, **86,** 214).

Large deposits of Vindhyan limestone are found in Bikaner division ; detailed surveys have yet to be carried out. In Palana region, 2–3 bands of nummulitic limestone (CaO, 42.16%), 1½–2 ft. thick, occur as intercalatory seams between the surface and the lignite seam ; thicker beds are also noted at places.

In Bundi dist., extensive deposits of cement grade limestone (CaO, 42.55–48.44%) occur at Lakheri (25°40′ : 76°11′) in the foothills of the main ridge extending from north-east to south-west. Flaggy limestone occurs in the upper and lower series, while good quality limestone with intercalatory shales is found in the middle series. Limestone is quarried at several places, the daily output being *c.* 45 thousand tons.

In Dungarpur, several limestone bands extending from north-west to south-east occur *c.* ½ mile east of Munger (23°52′ : 74°12′) ; the western bands are exposed at Nandli Anjni (23°55′ : 74°11′) and Dad (23°58′ : 74°10′) over a stretch of 8 miles.

In Jodhpur division, extensive deposits of Vindhyan limestone of chemical grade ($CaCO_3$, 95.6–97.3%) are exposed at Sojat (25°56′ : 73°40′) and run north past Bilara (26°11′ : 27°41′) in an outcrop 2–10 miles wide up to Gotan (26°39′ : 73°45′) and again extend for many miles beyond to the north-west. At Sojat, limestone is obtainable in various shades of colour, from cream to black, and at places is copiously seamed with chert. Gotan limestone (CaO, 53.99–55.24%) is dark grey to light grey in colour and occurs in the form of a 5–6 ft. thick bed underneath a overburden (5–8 ft.) composed of soil, *kankar* and altered flaggy limestone. The reserves in the area south of Gotan railway station is estimated at 8.8 million tons/sq. mile. In Nagaur dist. of Jodhpur division, large deposits of marble are found at Makrana (27°31′ : 74°43′) and the adjoining area : the main deposit is in the form of a hill running in the N.NE–S.SW direction, from Mataji-ka-temple to Kala Dungri, a distance of 12 miles. The deposits are extensively quarried. Important limestone deposits are located also at Mundwa, Manda, Amersagar and Athara (Sethi, 127 ; Roy, *Mem. geol. Surv. India*, 1959, **86,** 217).

In Sawai Madhopur dist. (Jaipur division), the ridge between Niladonga (Kailadevi) and Maloli contains cement grade limestone. Other important limestone bearing localities in Jaipur division are : Bandhya, Makholi, Kukas, Patan, Naila, Rahori and Raialo (Sethi, 125).

Limestone of the Nimbahera and Lower Bhander stages of the Vindhyans occur in Kotah division. The low-magnesia Nimbahera limestone (CaO,>43%) deposit occurs between Julmi (24°35′ : 75°59′) and Mailo (24°39′25″ : 75°58′40″) and between Nimana (24°41′30″ : 75°59′) and Deoli (24°48′30″ : 75°52′), a length of *c.* 20 miles. Massive, lower Bhander limestone (CaO, 26.08–43.21%), usually low in silica and alumina, is exposed as a continuous scarp in Mukandwara hill range for a distance of *c.* 34 miles. Travertine deposits are also noticed along the road near Kasar.

In Udaipur dist., multicoloured limestone is quarried near Chitorgarh railway station for building purposes ; the limestone ($CaCO_3$,>75%) is low in magnesia. It outcrops over an area of 7 sq. miles and the reserves within a depth of 20 ft. are estimated at 283 million tons (Roy, *Mem. geol. Surv. India*, 1959, **86,** 219).

In the Abu Road region, limestone occurs in several localities, notably at Pandore (24°32′ : 72°52′), Akhra (24°30′30″ : 72°50′), Murthala (24°31′ : 72°49′), Kivarli (24°32′ : 72°50′), Abu Road (24°28′30″ : 72°47′) and Dhanwau (24°31′ : 72°47′30″) : the total reserves in these localities are estimated at 15 million tons ; the deposit at Murthala carries 9.3 million tons of limestone (Roy, *Indian Miner.*, 1956, **10,** 103).

Limestone of good quality occurs near Kala Khokhra, *c.* 7 miles west of Maonda railway station and in Khetri area.

Kankar occurs throughout the State in small scattered deposits (Sethi, 122).

UTTAR PRADESH

Mirzapur district—A belt of Rohtas limestone runs along the left bank of Son river, in the lower slopes of Kaimur scarp, traversing the whole of Mirzapur dist., from east to west, over a distance of 80 miles. Deposits of calcitic limestone have been found near Kusdand (24°9′ : 82°54′), the outcrop is traceable for a distance of 2 miles and is *c.* 500 yd. wide. Cement grade limestone is found at Makribari (24°35′ : 83°8′), Rudauli (24°34′ : 83°8′), Pataudh (24°32′ : 83°5′), Kanch (24°22′ : 83°6′), Markundi (24°26′ : 83°5′), in Kandhaura–Mahona tract and between Mahona and Basuhari (24°32′ : 83°30′). Several large exposures are found north of Susnai and west of

Thiria. Limestone, somewhat high in magnesia, occurs in Ghaghra river and in Kanch-Kandhaura tract. Large occurrences of Kajrahat stage limestone is found extending east–west for a distance of *c.* 15 miles from Rihand river to Hardi (24°28′:83°13′); the most important outcrops occur at Kotah (24°27′: 83°8′) near the confluence of Kanhan river and Son river, where limestone of very high grade (CaO, 53; SiO_2, <3: and MgO, <1%) forms a series of small hills [Nath, *Indian Miner.*, 1959, **13,** 310; Nath, *Bull. geol. Surv. India, Ser. A*, No. 2, 1951, 1; Mathur, *Rec. geol. Surv. India*, 1958, **88**(1), 84; Narayana Rao, *Mineral Wealth of Uttar Pradesh*, 1956, 6].

Calcite and crystalline limestone deposits occur *c.* 3 miles south of Belwadah (24°12′:82°56′). The reserves in this area are estimated at 360 thousand tons of calcite and 2.8 million tons of crystalline limestone within a depth of 25 ft. (Mehta, *Bull. geol. Surv. India, Ser. A*, No. 2, 1951, 43).

Dehra Dun & Tehri-Garhwal districts—Extensive deposits of cement grade limestone occur in Kalsi, Dehra Dun, Mussoorie and Lachmanjhula areas. A deposit containing several million tons of workable siliceous limestone occurs at Mandarsu (30°30′: 77°55′) near Kalsi; some bands may become payable after flotation.

An Upper Krol limestone formation, 260–1,000 ft. thick, occurs throughout the Dehra Dun–Mussoorie area, from Sisoli (30°23′:78°8′) to Cloud End (30°28′:78°0′), a distance of over 11 miles. The main limestone band which is grey or bluish grey in colour analyses to 50–55% CaO, with magnesia from trace to slightly above 4%. Quarriable reserves are estimated at 404 million tons, of which the average quality material (CaO, 45.77: MgO, 4.95%) amounts to 254.5 million tons; chemical grade limestone (CaO, 50–55%), 143 million tons, and high grade stone (CaO, >55%), 6.5 million tons (Mehta *et al.*, *Bull. geol. Surv. India*, No. 16, 1959, 20).

A band of cement grade limestone occurs in Ghorapitti hills and in the region from Barkot near Doiwala up to the eastern spur of Kutia ridge. The reserves in Ghorapitti hills have been estimated at 12 million tons and in Barkot-Kutia ridge, at 38 million tons.

In Tehri-Garhwal dist., limestone of cement quality occurs at high altitudes near Kwanu rest house, south and west of Chakrata and Nagini; calcite marble occurs on the mule path from Narendranagar to Tehri [Auden, *Indian Miner.*, 1948, **2,** 83; Coggin Brown & Dey, 334; Auden, *Rec. geol. Surv. India*, 1954, **79**(2), 437; Nautiyal, ibid., 1953, **84**(1), 98].

In Garhwal dist., siliceous limestone bands occur near Nilkant, Pundras, Toli, Bhadsi and Manikot; the total reserves in this area are estimated at 28 million tons. Extensive deposits of calc-tufa occur in the neighbourhood of Chunakhan (29°19′:79°15′) near Naini Tal [Prakash & Zuberi, *Preliminary Rep. on the Limestone Deposits near Nilkant* (*Garhwal Dist.*), Directorate of Geology & Mining, U.P., 1957: Auden, *Rec. geol. Surv. India*, 1955, **79**(2), 550].

In Hardwar dist., outcrops of Upper Tal limestone are found above Lachmanjhula and along the river Ganga near co-ordinates 30°4′:78°30′.

Marl is found in fairly large quantities in the valleys of Gomti, Ghagra and Sai rivers [Puri, *Quart. J. geol. Soc. India*, 1948, **20**(2), 45].

WEST BENGAL

In the Purulia dist., several deposits occur in Jhalda, Hanshapathar, Baghmundi, Thaldu and Panchet hill areas. A few miles north of Jhalda (85°58′:23°22′), a thick belt of calcite ($CaCO_3$, >75%), covering 2–3 miles area and suitable for cement manufacture is exposed, the reserves in this area is reported to be large. In Bankura dist., outcrops of crystalline dolomitic limestone are found in the neighbourhood of Guniada hillock and Harirampur (23°8′:86°45′); *c.* 0.25 million tons of crystalline limestone may be available for every 10 ft. of depth in the latter locality. In Darjeeling dist., limestone of good quality and also calcareous tufa are found in several localities [Bhattacharjee, *Quart. J. geol. Soc. India*, 1958, **30,** 243; Banerjee, *Indian Ceram.*, 1958–59, **5,** 199; Hunday, *Rec. geol. Surv. India*, 1954, **85**(1), 69; Chatterjee, ibid., 1958, **88**(1), 120; Bijawat, *Chem. Age, India*, 1957, **8,** 182].

Demand and Reserves

Demand—Limestone is abundantly available in the country for meeting the requirements of building, cement, chemical and metallurgical industries. Cement grade limestone is available in practically all States. The demand for high quality limestone required for chemical and metallurgical industries is continuously rising and investigations have been undertaken in recent years to assess the extent and quality of deposits in various States. Table 5 lists the more important limestone deposits which supply lime to the chemical industry.

TABLE 5—CHEMICAL GRADE LIMESTONES, THEIR ANALYSES AND USES*

Location of deposit	Used for the manufacture of:	Average analysis
Andhra Pradesh		
Dronachalam	Sugar	avail. CaO, 80%
Assam		
Sylhet	Calcium carbide	$CaCO_3$, 95.4–98.6; $MgCO_3$, 0.55–1.87; SiO_2, 0.25–0.63; Al_2O_3, Fe_2O_3, etc., <2%
Bihar		
Latehar	Window glass	CaO, 53.2; MgO, 1.1; SiO_2, & insol., 2.2; Al_2O_3, 0.4; Fe_2O_3, 0.4; loss on ignition, 42.8%
Gujarat		
Porbandar	Soda ash & caustic soda	$CaCO_3$, 93.87; $MgCO_3$, 0.70; SiO_2, 1.66; R_2O_3†, 2.71; NaCl, 0.06; moisture, 0.94%
Okhamandal (Coral limestone)	do.	$CaCO_3$, 91.87; $MgCO_3$, 2.26; SiO_2, 2.07; R_2O_3†, 0.79; NaCl, 0.04; $CaSO_4$, 0.84%
Saurashtra (Pearl shells)	Bleaching powder	Lime: avail, CaO, 91.15–93.58; SiO_2, 0.17–0.39; R_2O_3†, 0.48–1.51%
Madhya Pradesh		
Katni	Calcium carbide, bleaching powder & sugar	CaO, 53–54; MgO, 0.75–1.0; SiO_2, 1–4; R_2O_3†, 0.5–1%
Jukehi	Bleaching powder, paper & sugar	CaO, 50–54; MgO, 0.5–1.5; SiO_2, 1–6; R_2O_3†, 0.25–1.5%
Maihar	Paper	CaO, 52.73–53.45; MgO, 0.48–1.05; SiO_2 & insol., 2.06–3.59; R_2O_3†, 0.66–0.86%
Satna	Paper	CaO, 45–50; SiO_2, 4–10; R_2O_3†, 1–2%
Madras		
Sankaridrug	Bleaching powder	CaO, 54–55; MgO, 0.5–1.0; SiO_2 & insol., <1.0; R_2O_3†, <0.5%
Mysore		
Yadwad	Sugar	CaO, 53.31; MgO, 0.71; SiO_2, 2.2%; Fe & Mn, in traces; free from S, P, Cl
Orissa		
Birmitrapur	Paper	CaO, 45.9–49.4; MgO, 2.1–3.5; SiO_2, 2.8–10.1; R_2O_3†, 1.2–2.9%
Rajasthan		
Makrana	Glass sheets	CaO, 50.4; MgO, 2.28; Fe_2O_3, 1.16; insol., 3.8%
Gotan	Calcium carbide	CaO, 54.8; MgO, 0.47; SiO_2, 0.65; R_2O_3†, 0.2%
Uttar Pradesh		
Dehra Dun	Sugar	CaO, >51; MgO, 1.3–3.3%

*Bijawat & Sastry, 112–17, 35; Macedo, 58, 84; Coggin Brown & Dey, 321–45; Dutt, *Indian Min. J.*, 1957, **5** (10), 33.
†Al_2O_3+Fe_2O_3.

Limestone is required in steel plants in two grades, one for fluxing in the blast furnace and the other for fettling in the steel melting shops. The requirements of flux grade and fettling grade limestone are *c.* 4 million tons and 0.8 million tons respectively per year. The present demand is met by deposits located in Orissa, Madhya Pradesh and Mysore. Bhilai steel plant draws its supplies from Nandini mines (Madhya Pradesh), Rourkela from Purnapani (Orissa) and Satna-Maihar (Madhya Pradesh) areas and Durgapur from the Hathibari-Birmitrapur area (Orissa). Table 6 lists the deposits which are supplying flux grade limestone to metallurgical industries along with a few promising deposits which may be quarried later [Indian Minerals Yearb., 1959, 207; *Industr. India*, 1959, **10**(10), 13].

Reserves—Correct estimates of reserves in various States are not available. Table 7 summarizes the available information. Actual reserves may be many times more than the figures mentioned.

Mining

Limestone deposits are worked in India by open cast quarrying. Quarrying is usually effected by manual operation. The overburden is removed and limestone broken into pieces by hammer and crowbar. Of late, a number of major mines have been mechanized. In 1959 there were 137 limestone mines in the country. Of these, 5 mines produced over 500 thousand tons, 19 mines over 50 thousand tons, 36 mines over 10 thousand tons and 65 mines up to 10 thousand tons of limestone per year (Indian Minerals Yearb., 1959, 207).

In Rajasthan, dimensional stones and marbles are

TABLE 6—FLUX GRADE LIMESTONE DEPOSITS*

	Extent of deposit	Remarks
Andhra Pradesh		
Cuddapah & Kurnool dist.	Ample reserves	Not utilized at present due to distance from consuming centres
Assam		
Sylhet	Extensive	Good quality flux grade stone; not exploited due to transport difficulty
Bihar		
Chota Nagpur	Scattered	..
Shahabad dist.	Large reserves	May be exploited later
Gujarat		
Kutch	Limited	..
Madhya Pradesh		
Jukehi–Kaimur area		Not exploited due to distance from steel plants
Nandgaon, Bhanpuri & Nandini	Large reserves	Bhanpuri & Nandini limestone used in Bhilai steel plant
Mohtara	10 million tons	
Madras		
Salem dist.	Good quantity	Used locally in low shaft furnaces
Maharashtra		
Chanda & Yeotmal	Limited	..
Mysore		
Shimoga, Chitaldrug, Tumkur & Mysore dist.	Total reserves, 50 million tons	Shimoga limestone used in *Mysore Iron & Steel Works*
Orissa		
Birmitrapur, Hathibari, Purnapani & Lanjiberna	96 million tons at Birmitrapur alone	Supply needs of Rourkela, Durgapur and Jamshedpur steel plants

* Engineer, *Indian Constr. News*, 1959, **8**(8), 96.

obtained by simple quarrying methods; holes are drilled to form a line of break after removal of overburden; and advantage is taken of joints, fissures or cracks for extraction. Cutting and dressing of stones for building purposes are done manually by chisel and hammer. Slabs up to 12 ft. in length are quarried.

Beneficiation The *Associated Cement Company* (ACC) has installed a beneficiating plant at Khalari (Bihar) for upgrading low grade limestone (CaO, 36%) from nearby deposits. The mineral is crushed, ground and fed to a battery of flotation cells of the Fagergreen type. Fatty acids are employed as flotation agents, methyl isobutyl carbinol as frother and a proprietary product, resembling blown oil, as collector. The concentrates are thickened in a Dorr-thickener. Beneficiated limestone (CaO content, 48.7%) is used for making cement [Dewan, *Indian Min. J.*, 1957, **5** (spec. issue), 53; Majumdar, ibid., 1955, **3**(10), 5; *Indian Miner.*, 1955, 9, 118].

Optimum conditions for beneficiation of limestone rejects from cement factories have been worked out in the National Metallurgical Laboratory, Jamshedpur, using oleic acid as collector and sodium silicate as depressant. Concentrates suitable for cement manufacture (CaO content, 45–47%) have been recovered with 80–88% yield [*CSIR News*, 1960, **10**(3), 3].

Limestone of flux grade should preferably be low in silica, alumina and magnesia contents. Silica and alumina are essentially inert materials which require additional flux and coke to remove them. Magnesia being a refractory material requires higher temperature for smelting involving higher fuel consumption. Efforts are therefore being made to beneficiate flux grade limestone by crushing and froth-flotation. The beneficiated fines obtained have, however, to be agglomerated for use in furnaces. Preliminary investigations using molasses or sodium silicate as binding agents carried out at the research laboratory of the *Tata Iron & Steel Co. Ltd.*, Jamshedpur, have yielded promising results [Kutar, *Iron & Steel Rev.*, 1959-60, **3**(11), 27].

TABLE 7—ESTIMATED RESERVES OF LIMESTONE*
(million tons)

	Cement grade	Flux grade	Ordinary	Total
Andhra Pradesh	3,848	..	6,222	10,070
Assam	1,154	..	..	1,154
Bihar	24	..	4	28
Gujarat	295	..	..	295
Jammu & Kashmir	17	..	..	17
Madhya Pradesh	134	85	11	230
Madras	10	..	..	10
Mysore	735	..	..	735
Orissa	90	46	64	200
Punjab	24	..	..	24
Rajasthan	292	15	..	307
Uttar Pradesh	4,788	2,984	..	7,772
Total	11,411	3,130	6,301	20,842

* Information from Indian Bureau of Mines, Nagpur.

TABLE 8—SPECIFICATIONS FOR LIMESTONE AND LIME*

Flux in iron & steel industry**	CaO, 47.5–49.60 ; $SiO_2+Al_2O_3$, 4.76 7.65 ; MgO, 1.86–4.1% ; should be dense fine grained, compact and able to withstand load in the furnace ; specifications for open hearth fettling grade stone more rigid, esp. with respect to $SiO_2+Al_2O_3$, than for blast furnace material
Cement manufacture‡	$\frac{CaO}{R_2O_3}$ (in percentage) after deducting lime necessary to combine with SO_3 present, 0.66–1.02 (i.e. CaO, $\nless$40 ; SiO_2, 14–15%†) ; MgO (max.), 2.7 ; Fe compd. (max.), 2 ; P_2O_5 (max.), 1%
Colourless glass††	$CaCO_3$ (min.), 94.5 ; $CaCO_3+MgCO_3$, 97.5 ; Fe_2O_3 (max.), 0.20 ; total non-volatile matter insoluble in HCl (max.), 2.0 ; moisture (max.), 3%
Sugar manufacture	CaO (min.), 50.0 ; MgO (max.), 1.0 ; SiO_2 & insol. (max.), 4.0 ; $Fe_2O_3+Al_2O_3$ (max.), 1.5%
Soda ash	$CaCO_3$, 90–99 ; $MgCO_3$, 0 6 ; $SiO_2+Al_2O_3+Fe_2O_3$, 0 3%
Calcium carbide	Quicklime: CaO (min.), 92.00 ; MgO (max.), 1.75 ; SiO_2 (max.), 2.00 ; $Fe_2O_3+Al_2O_3$ (max.), 1.00 ; S (max.), 0.20 ; P (max.), 0.02 ; loss on ignition (max.), 4.00 ; Fe_2O_3, $\ngtr$0.5% ; shall be in lump or pebble form and substantially free of core, ash and dirt
Bleaching powder	Quicklime: CaO (min.), 95.0 ; MgO (max.), 2.0 ; SiO_2 (max.), 1.5 ; $Fe_2O_3+Al_2O_3$ (max.), 2.0 ; Fe_2O_3, 0.3%
Sulphite pulp	Calcium lime: CaO (min.), 92.5 ; MgO (max.), 2.0 ; $Fe_2O_3+Al_2O_3+SiO_2$ (max.), 3.0%

* Bijawat & Sastry, 100–105.
** Engineer, *Indian Constr. News*, 1959, **8**(8), 104.
‡ BS: 12 (1947) ; $R_2O_3=2.8\ SiO_2+1.2\ Al_2O_3+0.65\ Fe_2O_3$.
† Indian Minerals Yearb., 1959, 206.
†‡ IS: 997-1957.

Uses and Specifications

Limestone is extensively used in building construction and masonry walls and as concrete aggregate, railroad ballast, asphalt filler and road metal. The principal use of limestone is in the manufacture of Portland cement. The use of limestone and marble for building purposes has already been dealt with under Building Stones (Wlth India—Raw Materials, I, 235–49).

It is employed also as a flux in the iron and steel industry. For every ton of steel produced over ½ ton of limestone is required.

Lithographic limestone which is fine-grained, porous and soft, is used in printing and engraving work. Iceland spar finds use in optical instruments ; a familiar example of such use is in the Nicol prism.

Calcium carbonate which may be in the form of ground limestone, marble, chalk or whiting, is used as a constituent of pottery glazes and enamels. Whiting prepared by crushing certain varieties of Porbandar stone or Jabalpur marble is used as an extender for paints and as filler for textiles, paper, rubber, soap and toilet powders. Chalk is used in the manufacture of putty and crayons.

Lime used in chemical, metallurgical, paper, sugar, textile and other industries, is produced by calcination of limestone. Substantial quantities of lime are produced in batch type country kilns or *bhattas* of various shapes, sizes and designs ; the quality of the product is generally poor. The bulk of chemical lime is produced in shaft kilns ; rotary kilns are also used for this purpose, but their number is small (Bijawat, *Chem. Age, India*, 1957, **8**, 171).

Specifications—Table 8 gives the specifications for limestones and lime used for different industrial purposes.

Production and Trade

The production of limestone has increased considerably during the last decade. Bihar is the leading producing State, closely followed by Madhya Pradesh and Orissa. Other important producing States are Rajasthan, Madras and Mysore. Table 9 gives the production during 1948–60. Statewise production of limestone during 1957–60 is given in Table 10. Only a small quantity of limestone, excluding building stones, is exported from India. The exports during

TABLE 9—PRODUCTION OF LIMESTONE IN INDIA

Year	Qty (thousand tons)	Val. (thousand Rs.)
1948	1,515	6,082
1949	1,980	7,230
1950	2,268	6,662
1951	2,918	10,258
1952	2,787	9,222
1953	4,072	16,791
1954	6,164	22,015
1955	7,366	30,248
1956	8,253	33,634
1957	9,420 (9,571)	37,336
1958	10,366 (10,533)	41,531
1959	10,660 (10,831)	45,723
1960	12,525 (12,726)	56,214

Figures in parentheses denote quantity in metric tons.

15

TABLE 10—STATEWISE PRODUCTION OF LIMESTONE DURING 1957-60
(Qty in thousand metric tons and val. in thousand Rs.)

	1957		1958		1959		1960†	
State	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.
Andhra Pradesh	491.2	1,024	758.3	2,101	909.8	2,793	920.4	2,706
Assam	76.0	580	66.2	505	61.0	466	49.2	381
Bihar	1,522.7	7,150	1,804.9	8,647	1,753.8	9,121	2,051.2	11,218
Gujarat & Maharashtra	627.4	1,884	557.2	1,865	458.7	2,051	719.6	3,306
Madhya Pradesh	1,067.8	2,905	1,296.7	4,203	1,410.5	5,291	1,990.5	10,300
Madras	1,134.6	3,105	1,180.8	3,454	1,274.3	3,914	1,613.6	5,446
Mysore	927.8	2,714	931.8	3,040	975.9	3,326	1,036.1	3,507
Orissa	1,384.9	8,097	1,500.1	8,713	1,556.3	10,096	1,769.1	10,710
Punjab	527.1	1,894	656.1	1,066	591.2	1,251	606.6	1,145
Rajasthan	1,294.5	5,425	1,330.3	5,816	1,417.4	5,941	1,591.1	6,382
Uttar Pradesh	490.4	2,477	444.6	2,101	417.6	1,447	376.7	1,097
West Bengal	26.6	81	6.3	20	4.9	26	2.2	16
Total	9,571.0	37,336	10,533.3	41,531	10,831.4	45,723	12,726.3	56,214

† Provisional

1957, 1958, 1959 and 1960–61 were (in tons) 93,147 (val. Rs. 705,701), 91,036 (val. Rs. 674,402), 104,047 (val. Rs. 744,686) and 98,335 (val. Rs. 741,458) respectively. Exports were mainly to East Pakistan.

Prices—The f.o.r. price for limestone containing 90–95% $CaCO_3$ ranged between Rs. 7 and Rs. 9 per ton in 1957, while the average price f.o.r. Katni in 1958, 1959 and 1960 was Rs. 10.50, Rs. 10.50 and Rs. 11.0 per ton respectively.

LIMNANTHEMUM Gmel.* (*Gentianaceae*)

A small genus of aquatic herbs, floating or creeping, found throughout the tropical, sub-tropical and temperate regions of the world. Five species occur in India.

L. cristatum Griseb.

D.E.P., IV, 641 ; III, 318 ; Fl. Br. Ind., IV, 131.

Hindi—*Tagarmul, cumuda, ghainchu ;* Beng.—*Panchuli, chandmalla ;* Mar.—*Kolare chikal ;* Tel.—*Anthara thamara.*

Bombay—*Khatara, kumudini ;* Mundari—*Marang chatom ara ba.*

An aquatic herb with long floating stem (stolon) rooting at the nodes, common in fresh-water jheels, tanks, ditches and ponds almost throughout India. Rhizome short, erect ; leaves, 2.5–10 cm. in diam.,

FIG. 42. LIMNANTHEMUM CRISTATUM—FLOWERING PLANT

* The genus is considered by some authors to be a synonym of *Nymphoides* Hill

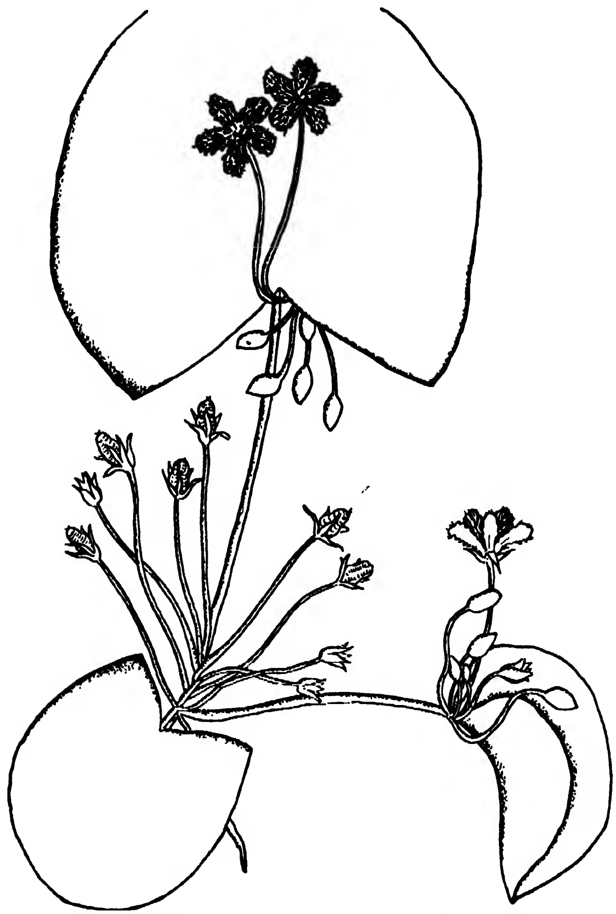


FIG. 43. LIMNANTHEMUM INDICUM—FLOWERING PLANT

orbicular, purplish beneath; flowers white, yellow within, in dense clusters; capsules broadly ovoid or sub-globose with numerous seeds. The plant reproduces vegetatively as well as by seeds; vegetative propagation is more frequent. Flowering takes place throughout the summer months (d'Almeida, *J. Indian bot. Soc.*, 1928, **7**, 1 : Mitra, *Proc. nat. Inst. Sci. India*, 1955, **21B**, 170).

The plant is used as a substitute for chiretta (*Swertia chirata* Buch.-Ham.) in fevers and jaundice. Stalks and leaves are pounded with oil and applied to ulcers and insect bites; and a decoction is used as a wash for parasitic skin affections. Seeds are considered anthelmintic. Stems, leaves and fruits are eaten, either in curry or after boiling (Kirt. & Basu, III, 1669; Chopra, 503; Burkill, II, 1346).

L. indicum (Linn.) Thw.

Fl. Br. Ind., IV, 131.

HINDI—*Bara chuli*; MAL.—*Chinnambal*.

MUNDARI—*Sadom lachomkor ba*.

An aquatic herb closely resembling *L. cristatum*, but with thicker rhizome, stouter stolon and larger leaves found in tanks, ponds and ditches nearly throughout India. Stems long, floating, rooting at nodes; leaves floating, 30 cm. or more in diam.; flowers white with yellow centres, in clusters. The plant propagates itself by vegetative buds and adventitious roots (d'Almeida, loc. cit.).

The rhizomes, roots, stolons and petioles of the plant are used as vegetable. The plant is bitter and used as antiscorbutic and febrifuge [Bressers, 95; Santapau, *Rec. bot. Surv. India*, 1953, **16**(1), 183; Watt & Breyer-Brandwijk, 141].

L. nymphaeoides Link

D.E.P., IV, 641; III, 429; Fl. Br. Ind., IV, 131; Blatter, II, Pl. 43, Fig. 5.

PUNJAB—*Kuru, khairposh*.

An aquatic herb with creeping rhizome found in western Himalayas at altitudes of 1,800–2,700 m. Stems long, floating, rooting at nodes; leaves 2.5–5 cm. in diam., round, deeply cordate; flowers yellow, in axillary umbels; capsules 2.5 cm. long, ellipsoid, sharp-pointed with many seeds. The plant is common in ditches along roads in Dal district in Kashmir (Blatter, II, 49).

The plant is largely used as fodder; it increases the flow of milk of cows feeding on it. Fresh leaves are useful for periodic headaches (Kirt. & Basu, III, 1669).

LIMNOPHILA R. Br. (*Scrophulariaceae*)

A genus of herbs found throughout Africa, Asia and Australia. About 20 species occur in India. Some are strongly aromatic and are often used as pot-herb or flavouring.

L. aromatica (Lam.) Merrill syn. *L. gratissima* Blume

Fl. Br. Ind., IV, 268; Kirt. & Basu, Pl. 696A.

HINDI—*Kuttra*; BENG.—*Karpur*; MAR.—*Ambuli*; MAL.—*Manganari*.

A stout aromatic herb, 30–50 cm. high, found in South Bihar, Orissa, Sundarbans, Aka hills (Assam), Deccan and western parts of S. India up to 600 m., in damp places, margins of ponds and backwaters. Leaves sessile, linear-oblong or lanceolate, sharply serrate; flowers small, in axillary and terminal racemes; capsules small, ovoid-oblong.

The plant possesses the odour of turpentine and yields 0.13% of an essential oil containing *d*-limonene and *d*-perillaldehyde as the principal constituents. It is used as spinach in Java and eaten raw or steamed. It is regarded as antiseptic, galactagogue

and aperient. Leaves are applied as poultice for sore on legs. The juice of the plant is given in fever and to nursing mothers when the milk is sour (*Chem. Abstr.*, 1947, **41**, 3262; Burkill, II, 1347–48; Kirt. & Basu, III, 1814; Chopra, 503).

L. indica (Linn.) Druce syn. *L. gratioloides* R. Br.; *L. racemosa* Benth.

Fl. Br. Ind., IV, 271; Chatterjee & Bharadwaja, *Bull. bot. Soc. Beng.*, 1955, **9**, 138; Kirt. & Basu, Pl. 696B.

HINDI—*Kuttra*; BENG.—*Karpur*; MAR.—*Ambuli*; GUJ.—*Turati*; MAL.—*Manganari*.

MUNDARI—*Losod ara*.

A short, erect, diffusely branched herb, up to 30 cm. high, found in damp places, swamps and rice fields throughout India ascending to 900–1,200 m. in the Himalayas. Leaves linear-oblong: upper leaves sessile, lower leaves submerged, sometimes capillaceo-multifid; flowers solitary, axillary or in terminal racemes; capsules small, broadly ellipsoid or globose.

L. indica is a variable species. Two varieties are usually met with: var. *elongata* Benth. found in upper Gangetic plain, Madhya Pradesh and Deccan and var. *intermedia* Hook. f. found in upper Gangetic plain and N. W. Himalayas; these are regarded by some authors as eco-forms of *L. indica*. The plant flowers during the rainy and cold seasons.

The plant has a refreshing and agreeable odour resembling that of camphor or oil of lemons. Leaves are eaten as pot-herb. The plant is reported to possess antiseptic and carminative properties. A liniment prepared from the plant is used in elephantiasis. An infusion of leaves is given in Philippines for dysentery and dyspepsia (Dymock, Warden & Hooper, III, 7; Bressers, 105; Kirt. & Basu, III, 1814; Chopra, 503; Quisumbing, 870).

L. rugosa (Roth) Merrill syn. *L. roxburghii* G. Don

Fl. Br. Ind., IV, 265; Chatterjee & Bharadwaja, *Bull. bot. Soc. Beng.*, 1955, **9**, 137.

BENG.—*Kala karpur*.

MUNDARI—*Losod ba*.

An erect herbaceous, aromatic annual, 30–60 cm. high, found in aquatic situations and moist lands almost throughout India ascending to 1,800 m. in the Himalayas. Leaves elliptic to ovate, crenate-serrate or crenulate: flowers in axillary shortly pedunculate heads; capsules oblong-ellipsoid.

L. rugosa tastes like *Ocimum basilicum* Linn. and used as a flavouring for food. It is also used as hair perfume. Leaves contain an essential oil. The mineral constituents present in the ash of the plant (ash, 2.1%) are: phosphorus (P_2O_5), 0.15; calcium (CaO), 0.31; and iron (Fe_2O_3), 0.022%. An infusion of the leaves is taken as diuretic, stomachic and digestive tonic in the Philippines (Burkill, II, 1348; Brown, 1946, III, 326–27; Quisumbing, 871; Kirt. & Basu, III, 1815).

L. conferta Benth. (MAL.—*Munganari*; MUNDARI—*Muchri ara*) is an erect or procumbent herb, 30–45 cm. high, with elliptic-oblong leaves found more or less throughout India in damp places. It is used as a pot-herb by the Mundas (Bressers, 104).

Limonia — *see* **Feronia, Hesperethusa**

Limonite — *see* **Iron Ores**

Limpets — *see* **Molluscs**

Linaloe Tree — *see* **Bursera**

Linaria — *see* **Kickxia**

LINDENBERGIA Lehm. (*Scrophulariaceae*)

A small genus of annual or perennial herbs distributed throughout tropical Asia and Africa. Seven species are recorded in India.

FIG. 44. LINDENBERGIA INDICA—FLOWERING PLANT

L. indica (Linn.) Kuntze syn. *L. urticaefolia* Lehm. : *L. polyantha* Royle ex Benth. ; *L. ruderalis* (Retz.) Voigt

D.E.P., IV, 642 ; Fl. Br. Ind., IV, 262 ; Chatterjee & Bharadwaja, *Bull. bot. Soc. Beng.*, 1955, **9,** 139.

Beng. *Haldi basanta ;* Mar.—*Dhol, gajhdar ;* Guj. *Bhinta chatti, patthar chatti.*

Mundari—*Huring jiki pota.*

An erect, sometimes tufted, annual herb, 10–30 cm. high, found throughout India ascending to 2,100 m. in the Himalayas. Leaves broadly ovate or elliptic, crenately serrate ; flowers small, yellow, solitary or in clusters, sometimes forming axillary or terminal racemes ; capsules ovoid, laterally compressed, beaked, containing minute seeds. *L. indica* is a very variable species. It is commonly found in crevices on old walls and banks of ancient monuments (Fl. Delhi, 259).

The plant possesses a faint aromatic odour and is slightly bitter. The juice of the plant is given in chronic bronchitis ; it is applied also to skin eruptions (Kirt. & Basu, III, 1811).

LINDERA Thunb. (*Lauraceae*)

D.E.P., IV, 643 ; Fl. Br. Ind., V, 182.

A genus of dioecious or polygamous, aromatic trees and shrubs distributed in Asia and North America. About 15 species are found in India, chiefly in eastern Himalayas and Assam.

L. assamica Kurz (Nepal—*Sanu pahenle, paieli ;* Lepcha—*Senashelkung, phamlet ;* Assam—*Matabhe, bambhe, dieng-pakhar*) is a large shrub or a tree up to 18 m. in height and 1.5 m. in girth, with a clean bole 6–9 m. long, found in eastern Himalayas between 1,800 and 2,700 m. and in parts of Assam. Bark brownish ; leaves elliptic-lanceolate, coriaceous ; flowers in clusters, small ; fruit sub-globose. The wood (wt., 34–41 lb./cu.ft.) is yellow, turning olive grey on exposure, pretty, even-grained and moderately hard ; it is used for building purposes, chiefly as planks (Gamble, 574).

L. caudata Benth. (Khasi—*Dieng-soh-orthai, dieng-brau-salu*) is a small to medium-sized tree found in Khasi and Naga hills in Assam. In China, a decoction of the leaves is taken to relieve pain caused by mechanical injury (Cheo, *Bot. Bull. Acad. sinica*, 1949, **3,** 136).

L. neesiana Benth. (Nepal—*Siltimur*) is a small or medium-sized tree found in temperate Himalayas from Nepal eastwards at 1,800–2,400 m. and in Mishmi and Aka hills in Assam. The plant is aromatic, spicy and carminative. It is reported to yield sassafras which is possibly substituted for sassafras from *Cinnamomum glanduliferum* in Nepal (Chopra, 503 ; Kirt. & Basu, III, 2163 ; Wlth India—Raw Materials, II, 178).

L. pulcherrima Benth. (Hindi—*Dadia ;* Kumaon—*Cheri ;* Nepal—*Sissi ;* Lepcha—*Nupsor-kung ;* Khasi—*Dieng-tyrthia-synrang, dieng-jabu-rit*) is a medium-sized tree, 18–24 m. in height and 1.2–1.5 m. in girth, with a clear bole of 6–9 m., found in temperate Himalayas from Kumaon eastwards at altitudes of 1,200–2,700 m. and in Khasi hills and Manipur. The wood (wt., 33–40 lb./cu.ft.) is reddish white, even-grained and moderately hard. It does not warp easily and is used for building purposes, cattle yokes and occasionally for tea boxes (Gamble, 574).

LINDERNIA All. (*Scrophulariaceae*)

A large genus of annual herbs distributed throughout the tropics. The genus has been recently enlarged to include the three genera, *Bonnaya* Link & Otto, *Ilysanthes* Rafin. and *Vandellia* Linn. About 25 species are reported to occur in India (Pennell, 27 ; Mukerjee, *J. Indian bot. Soc.*, 1945, **24,** 130).

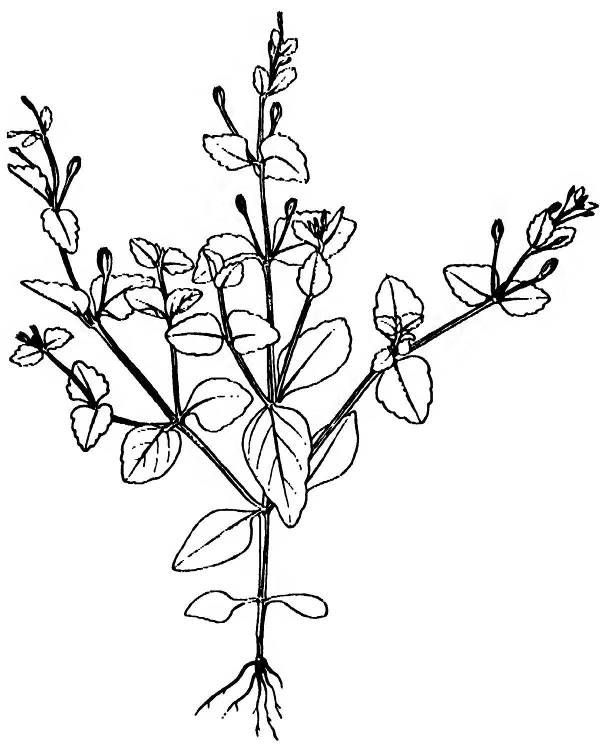


FIG. 45. LINDERNIA CRUSTACEA—FLOWERING PLANT

L. crustacea F. Muell. syn. *Vandellia crustacea* Benth.

Fl. Br. Ind., IV, 279 : Mukerjee, *J. Indian bot. Soc.*, 1945, **24,** 130.

A low, glabrous, diffusely branched annual, 3.5–30.0 cm. high, with small ovate, entire or serrate leaves and purple or blue-violet flowers. It is found throughout India ascending up to 1,600 m. in the Himalayas, in moist, open grassy places, rice fields, river beds and ditches.

The plant is reported to contain a bitter principle. It is used for bilious affections and dysentery in Indo-China. Elsewhere it is used in poultices for boils, sores, ringworm and itches (Wehmer, II, 1133 : Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37,** 546 ; Burkill, II, 1350).

L. cordifolia (Colsmann) Merrill syn. *Vandellia pedunculata* Benth. (MAR.—*Gadagvel*) and *L. pyxidaria* All. syn. *Vandellia erecta* Benth., *V. pyxidaria* Maxim. (MAR.—*Vakapushpi*) are found almost throughout India up to 1,200–1,700 m. in the Himalayas. They are used as a remedy for gonorrhoea. In Malaya, *L. cordifolia* is used as a substitute for *L. crustacea* (Kirt. & Basu, III, 1821 : Burkill, II, 1351).

L. oppositifolia (Retz.) Mukerjee syn. *Vandellia oppositifolia* Haines (MUNDARI—*Hendegel ba, garandi ara*) is a herb found in Bihar, Deccan, Carnatic, Bombay and west coast. The roots are used locally for fevers. *L. ruelloides* (Colsmann) Mukerjee syn. *Bonnaya reptans* Spreng. (GARO—*Sam-thamlang, sam-gichhok*), a creeping herb found in Nepal, Sikkim, Assam, Khasi and Garo hills, Orissa (Puri), Bombay and S. Konkan, is used in Lakhimpur (Assam) in external applications for worms in the skin (Bressers, 106 : Kirt. & Basu, III, 1822).

LINOCIERA Sw. (*Oleaceae*)

A genus of shrubs or trees distributed in tropical and sub-tropical regions. About 9 species are found in India.

L. ramiflora (Roxb.) Wall. syn. *L. intermedia* Wight (including var. *roxburghii* C. B. Clarke)

D.E.P., IV, 643 : Fl. Br. Ind., III, 609.

TEL.—*Satapala, cedaneredu* ; KAN.—*Kunde* ; ORIYA—*Musurdanta, sulinli-kuda*.

A shrub or a small to moderate-sized evergreen tree found in the sub-Himalayan tract from Ravi eastwards and in eastern, central and southern India up to an altitude of 1,800 m. Bark brownish ; leaves elliptic-oblong, up to 20 cm. long : flowers in panicles, small, whitish ; drupes ellipsoid, bluish purple, 1-seeded.

The wood is white or pale brown, moderately hard, close-grained and durable. It is used for agricultural implements and in turnery. In Malaya and Philippines, the wood is used for planking, posts and frames of dwellings and boats (Gamble, 473 ; Burkill, II, 1351).

The bark is bitter ; it is used for intermittent fevers in Queensland. The plant exudes a wax when injured by insects (Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 121 ; Wehmer, II, 959).

L. terniflora Wall.

Fl. Br. Ind., III, 610.

ASSAM—*Komponesilong-asing*.

A moderate-sized tree found in Sibsagar and Khasi and Lushai hills in Assam and in Andaman Islands. Bark greyish, fissured ; leaves elliptic to ovate-oblong, coriaceous ; flowers in panicles, small, white ; drupe ellipsoid, dark blue.

The wood is white with a pinkish tinge, turning pale brown with age, fine-textured, hard and heavy (wt., 49 lb./cu.ft.). It is suitable for turnery, brush backs, mathematical instruments, shuttles and bobbins, and for tool and axe handles [Chowdhury & Ghosh, *Indian For. Rec., N.S., Util.*, 1946, **4**(3), 13].

L. malabarica Wall. ex G. Don (TEL.—*Punagamu, punicce* ; TAM.—*Porumbalu* ; KAN.—*Hariyage* ; MAL.—*Kaletala* ; ORIYA—*Pochandia* ; KHANDALA—*Kumli, parjamb*) is a small or moderate-sized tree with broadly lanceolate leaves and fascicles of white fragrant flowers found in the forests of Deccan Peninsula. The tree is very attractive when in full bloom. The wood of this tree is reddish grey, lustrous, smooth, close-grained, hard and heavy (wt., 52–65 lb./cu.ft.) : it resembles boxwood [Talbot, II, 196 : Gamble, 473 : Santapau, *Rec. bot. Surv. India*, 1953, **16**(1), 163].

L. zeylanica Gamble syn. *L. purpurea* Vahl (TEL.—*Punisi* ; TAM.—*Kattumancari*) is a small tree found in the forests of South India. The wood (wt., c. 55 lb./cu.ft.) is yellowish white, hard and close-grained like boxwood. It is suitable for sash bars and light structural work (Fl. Madras, 794 ; Lewis, 272).

LINOSTOMA Wall. (*Thymelaeaceae*)

Fl. Br. Ind., V, 197.

A small genus of shrubs distributed chiefly in South-East Asia and Brazil. Two species are found in India.

L. decandrum Wall. (ASSAM—*Bakalbih, ruteng*) is an evergreen, erect or climbing shrub, commonly found in the forests of Assam up to an altitude of 1,500 m. in Lushai hills. Leaves oblong-lanceolate or elliptic-oblong, coriaceous; flowers fragrant, greenish white, in 6–10 flowered umbellate cymes; fruits broadly ellipsoid, hard or corky, with inflated perianth at base. The stem and fruit of this species are used for poisoning fish; they are highly toxic and kill all the fish in treated waters (Chopra, 1958, 587; Bor, 147).

Linseed — *see* **Linum**

LINUM Linn. (*Linaceae*)

A genus comprising mostly herbs and shrubs found in the temperate and sub-tropical parts of the world, particularly countries bordering the Mediterranean sea. Three or four species are recorded in India, of which *L. usitatissimum* is cultivated widely for its oil-seed. *L. bienne* Mill. syn. *L. angustifolium* Huds. and *L. grandiflorum* Desf. are grown in gardens for ornament.

L. mysorense Heyne

D.E.P., V, 1; Fl. Br. Ind., I, 411; Fyson, II, Pl. 44.

An annual glabrous herb, *c.* 47 cm. high, found in W. Himalayas at altitudes of 920–1,500 m. and in Punjab, Rajasthan and hilly regions of Deccan and western ghats. Flowers yellow, in panicled corymbs; capsule globose, 0.3 cm. diam., containing small flat, oval seeds. This plant is reported to be a collateral host, during summer and rainy season, of *Melampsora lini* (Ehrenb.) Lev., a serious rust on linseed plants in India (Mathur *et al., Indian Oilseeds J.*, 1956–57, **1**, 145).

L. perenne Linn.

D.E.P., V, 1; Fl. Br. Ind., I, 411.

A perennial herb, 30–90 cm. high, found in north-west Himalayas at altitudes of 3,000–4,000 m. Leaves lanceolate: lower oblong, upper linear-acute; flowers blue, in few flowered cymes; capsule as large as pea.

An ornamental plant suitable for mixed borders. The seeds are considered emollient in Europe and China (Gopalaswamiengar, 443; Kirt. & Basu, I, 410).

L. strictum Linn.

D.E.P., V, 1; Fl. Br. Ind., I, 411.

An annual herb, 30–50 cm. high, found in north-west Himalayas up to 3,500 m. and in Punjab. Leaves linear-lanceolate, rough; flowers yellow; capsule globose, 0.5 cm. diam.

This species is reported to be cultivated in Afghanistan for seed oil and fodder. The seeds are considered emollient in Spain (Kirt. & Basu, I, 411).

L. usitatissimum Linn. LINSEED

D.E.P., V, 2; C.P., 719; Fl. Br. Ind., I, 410.

SANS.—*Atasi;* HINDI—*Alsi, tisi;* BENG.—*Masina;* MAR.—*Javas;* GUJ.—*Alsi;* TEL.—*Avisi;* TAM.—*Ali-virai;* KAN.—*Agasi.*

An erect annual, 60–120 cm. high, cultivated throughout the plains of India and up to an altitude of 1,800 m.; flowers small, blue, bluish violet or white, in terminal panicles; fruits capsular, with five cells, each containing 2 seeds; seeds yellowish or blackish brown, small, flattened, oval, with smooth shining coat.

L. usitatissimum is unknown in a wild state and its origin is uncertain; it is considered by some to be closely related to, or derived from *L. bienne* Mill. syn. *L. angustifolium* Huds. which occurs wild in the Mediterranean region; some consider it to be indigenous to localities between the Persian gulf and the Caspian and Black seas, while others ascribe its origin to India. However, two main geographical groups corresponding to the oldest areas of cultivation and the centres of diversity may be recognized. Linseed has been cultivated since antiquity in the Mediterranean coastal lands, Asia Minor, Egypt, Algeria, Tunis, Spain, Italy and Greece; in all these areas, only fibre-flaxes are cultivated. The second group comprises south-west Asia, including Turkestan, Afghanistan and India; only oil types are grown in these areas. In Asia Minor and in South Russia, transitional forms are cultivated for both fibre and oil (Ames, 65; Vavilov, 31, 33, 36; Hector, II, 811).

The seeds of the plant yield on expression a quick-drying oil; the stalks yield flax, the well-known textile fibre. The end use determines the selection of *Linum* types for cultivation. Types grown for fibre are generally slender tall-growing, non-tillering and sparingly branched. Those grown for seed are usually dwarf in habit, much-branched and profusely tillering. *Linum* is cultivated in India entirely for the seeds; two ecological types may be distinguished: (*i*) Gangetic types of the alluvial soils of North India and (*ii*) Peninsular types grown south of Ganges and Jumna. Gangetic types possess shallow tap-roots while Peninsular types have roots which penetrate deep into the soil and develop secondary roots. The latter are generally quick-growing and early-

FIG. 46. LINUM USITATISSIMUM—HABIT IN PENINSULAR & GANGETIC TYPES

maturing, while alluvial types are slow-growing and late-maturing. Seeds of Peninsular types are large and rich in oil, but the yield of seed is low; those of alluvial types are small, poor in oil, but give high yields of seed. The Indo-Gangetic types and the Peninsular types are considered merely biological variants of the original ancestor of *L. usitatissimum* introduced from Central Asia: or they may be derivatives of crossing the original ancestor with *L. strictum* in the north, and *L. perenne* and *L. mysorense* in the south (Howard & Khan, *Mem. Dep. Agric. India, Bot.*, 1922–24, **12**, 135; Hunter & Leake, 90; Hector, II, 795).

Cultivation

Linseed is grown widely in many sub-tropical countries. Before the outbreak of World War II, Argentina was the leading producer with Soviet Union and India ranking second and third respectively. In recent years, U.S.A. and Canada, which were relatively unimportant as producers of linseed before the war, have expanded production. At present, U.S.A. is the largest producer, followed by U.S.S.R., India and Argentina; Canada and Uruguay occupy the fifth and sixth places (Table 1).

India at present accounts for *c.* 20% of the world acreage and 12% of production. Among the major oilseed crops grown in India, linseed accounts for *c.* 12% of the total acreage and occupies the fourth place (Table 2). The acreage under linseed is *c.* 39 lakhs and the production of linseed 4 lakh tons.

Linseed is grown all over the country, excepting in Kerala, Madras, Delhi, Manipur and Tripura and in Andaman and Nicobar Islands. Uttar Pradesh and Madhya Pradesh together account for nearly two-thirds of the total production. Uttar Pradesh is the largest producer accounting for more than 35% of the total production, the main areas being Mainpuri, Amirpur and Allahabad districts. Madhya Pradesh accounts for a little over 29% of production, the main areas being Drug, Raipur, Bilaspur, Rewa and Balaghat districts. Other important linseed producing States in order of importance are Bombay, Rajasthan and Bihar. The distribution of acreage and production of linseed in the various States in India is given in Table 3.

Climate & Soil—Linseed is cultivated throughout the plains of northern India. It is grown predominantly as a rainfed, cold season rabi crop. A moderate amount of rainfall (75–175 cm. per annum) is best suited for its growth. It grows in almost all types of soils where sufficient moisture is available, but thrives best in heavy soils with high moisture retaining capacity. It grows well in the black cotton soils of central and Peninsular India, particularly where *durum* wheats are cultivated. In such areas it competes with wheat, the preference for one or the other crop depending on the demand and price. In northern India, it is grown chiefly in the sub-montane districts and does best on heavy loam soil (Burns, 71).

Cultivated types—Indian linseed is classified into two broad groups for commercial purposes, namely, yellow and brown; the latter is further graded into bold, medium and small; different grades in the yellow group are not recognized for trade purposes, although for breeding purposes distinctions are made according to size of seed. Yellow types are preferable to brown types, because of the higher percentage of oil and lighter colour of oil and cake.

TABLE 1—ACREAGE AND PRODUCTION OF LINSEED IN DIFFERENT COUNTRIES *

Country	Area (thousand acres)					Production (thousand tons)				
	1938-39	1953-54 to 1955-56 (av.)	1956-57	1957-58	1958-59	1938-39	1953-54 to 1955-56 (av.)	1956-57	1957-58	1958-59
Argentina	6,689	1,766	3,176	3,576	3,166	1,425	365	610	620	610
Canada	210	1,339	3,041	3,486	2,623	31	341	862	479	569
India	3,783	3,498	4,156	3,318	3,708	429	394	384	249	430
Soviet Union†	5,931	3,155	4,744	4,176	3,954	450	308	600	550	560
United States of America	1,032	5,324	5,862	5,599	4,014	201	1,001	1,200	648	989
Uruguay	452	257	324	341	321	110	58	68	71	64
Others†	1,070	1,424	1,470	1,423	1,366	239	384	379	343	358
Total†	19,167	16,763	22,773	21,919	19,152	2,885	2,851	4,103	2,960	3,580

* *Vegetable Oils and Oilseeds*, Commonwealth Econ. Comm., 1960, 135, Tables 116 & 117. †Includes area cultivated for fibre and seed.

TABLE 2—ACREAGE AND PRODUCTION OF OILSEEDS IN INDIA

	Area (thousand acres)			Production (thousand tons)		
	1957-58	1958-59	1959-60	1957-58	1958-59	1959-60
Groundnut (pods)	14,876	14,575	15,305	4,436	4,812	4,390
Sesamum	5,171	5,500	5,510	354	511	392
Rape & Mustard	5,979	6,021	7,167	923	1,025	1,037
Linseed	3,129	3,965	3,921	249	447	425
Castor	1,184	1,203	1,178	89	112	108
Total	30,339	31,264	33,081	6,051	6,907	6,352

TABLE 3—ACREAGE AND PRODUCTION OF LINSEED IN DIFFERENT STATES IN INDIA

	Area (thousand acres)			Production (thousand tons)		
	1957-58*	1958-59*	1959-60*	1957-58*	1958-59*	1959-60
Madhya Pradesh	1,045	1,523	1,497	54	138	144
Uttar Pradesh†	769	893	847	80	158	143
Bombay	602	594	604	53	56	54
Rajasthan	240	294	298	20	27	25
Bihar	139	284	263	11	30	26
Mysore	127	128	122	11	10	9
West Bengal	46	95	135	5	11	10
Andhra Pradesh	75	68	72	5	4	4
Punjab		29	26			
Orissa		37	37		4	
Jammu & Kashmir	20	15	15		3	
Assam			3	(a)	1	1
Himachal Pradesh			2	(a)	(a)	(a)
Total	3,129	3,965	3,921	249	447	425

*Partially revised estimates. **Final estimate. †Data include crop grown pure as well as mixed. (a) below 500 tons.

Considerable work has been done in India in selecting types suitable for various States. About 123 types of linseed have been collected from various parts of India and grouped under 26 categories. The diploid chromosome number of Indian types is 30, while that of flax types, grown in Europe and other countries, is either 30 or 32. Attempts to grow flax types in India have met with little success (Howard & Khan, loc. cit.; Richharia & Kalamkar, *Indian J. agric. Sci.*, 1939, **9**, 561; Darlington & Ammal, 103; Hector, II, 811).

Interspecific hybridization involving the following crosses has been effected: *L. usitatissimum* × *L. bienne*; *L. usitatissimum* × *L. africanum*; *L. perenne* × *L. austriacum*. A large number of useful strains have been developed by transference and recombination of useful genes and some strains resistant to wilt or rust have been evolved. Further, by crossing Indian linseeds with foreign fibre types, strains useful for seed as well as fibre have been evolved. The characteristics of some of the types evolved as a result of acclimatization, selection and hybridization, and recommended for distribution in different States in India are given in Table 4 (Howard & Khan, loc. cit.; Graham & Roy, *Agric. J. India*, 1924, **19**, 28; Shaw *et al.*, *Indian J. agric. Sci.*, 1931, **1**, 1; Deshpande & Mallick, ibid., 1937, **7**, 841; Deshpande, *Indian J. Genet.*, 1950, **10**, 7; Deshpande & Jeswani, ibid., 1951, **11**, 2; 1954, **14**, 22; *Curr. Sci.*, 1955, **24**, 202; Singh *et al.*, *Indian J. Genet.*, 1956, **16**, 29).

Culture—In Peninsular India, seed is generally sown in October or even earlier and harvested in February, whereas in the Gangetic alluvium, it is sown in November and harvested in March or April. In the hilly districts of Uttar Pradesh, it is sown in September or October. In Kashmir, the crop is sown in February and March. Seeds are, as a rule, sown in lines, but in some areas, particularly for growing with a standing crop of paddy, seeds are sown broadcast; the latter system is called *utera* in Madhya Pradesh and *paira* in Bihar; under this system the sowing time is earlier by about a month. When sown in

I.A.R.I., New Delhi

FIG. 47. LINUM USITATISSIMUM—CROP

Bot. Division, I.A.R.I., New Delhi

LINUM USITATISSIMUM — FLOWERING & FRUITING BRANCHES AND SEEDS OF DIFFERENT TYPES

TABLE 4—CHARACTERISTICS OF SOME LINSEED TYPES DISTRIBUTED IN INDIA[1]

State	Improved strain	Season Sowing	Season Harvesting	Duration of crop (days)	Seed colour	Av. yield of seed/acre (lb.)	Oil (%)	Special features
Bombay	Linseed No. 3	Oct. Nov.	Feb.-Mar.	120	Dark brown	403	40-41	Bold seeded, high yielding, early ripening; suitable for Vidharba tract
	„ No. 55	do.	do.	120	do.	379	41-42	Bold seeded, high yielding, early ripening; suitable for Berar tract
	Malsiras No. 10	Early Oct.	Jan. end	110	Brown	430	41.1	High yielding; superior oil; suitable for Nasik tract
	Sholapur No. 36	do.	do.	115	do.	400	42.7	Bold seeded; suitable for Sholapur dist.
	Cross 4/29†	Oct.	Feb.	120	do.	417		High yielding, partially rust-resistant, early type; suitable for Vidharba
Bihar	Linseed Teesi (Imp., 1193/2)	Oct. Nov.	Feb.-Mar.	110	do.	1,500	41.5	
	P. 142	do.	do.	120	do.	1,442	42	
	BR-1	do.	do.	120	do.	445	42	
	BR-2	do.	do.	120	do.	816	42	
	BR-9	do.	do.	110	do.	261	42	
	BR-12	do.	do.	115	do.	313	42	
Madhya Pradesh								
(i) East & North M.P.	No. 3	Sept.-Oct.	Dec.-Jan.	120-150	Deep brown	208-403	40-41	Susceptible to wilt & rust
	No. 55	do.	do.	120-150	do.	180-380	41-42	do.
	No. 4/29	do.	do.	120-150	do.	203	..	do.
(ii) West M.P. (Malwa)	Mahoba	Oct. mid.	Feb. end	135	Brown	293	40.2	do.
	N.P. 11	do.	do.	135	Yellow	246	40	Resistant to wilt susceptible to rust
	I.P. 1-6	do.	do.	135	Brown	257	40.7	Susceptible to wilt & rust
	I.P. 11	Oct.	Mar.	150	White	210	42.3	
Orissa	Mayurbhanj	Oct. end	Feb. mid.	110	Brown, shining	800		Bold seeded, early ripening, rust & wilt resistant
Punjab	K-2	Oct.	Apr.	175	Brown	750	46.5	Bold seeded, early maturing, rust & wilt resistant, high yielding

TABLE 4—*contd.*

State	Improved strain	Season: Sowing	Season: Harvesting	Duration of crop (days)	Seed colour	Av. yield of seed/acre (lb.)	Oil (%)	Special features
Uttar Pradesh	Type No. 1	Mid Oct.	Early Mar.	135-140	Brown	1,200-1,600	40.9	Bold seeded, early, high yielding, rust resistant; suitable for Bundelkhand tract south of Jamuna & Ganges
	Type No. 126**	Oct.	Mar.	140-145	do.	800	41.4	Resistant to rust; bold seeded; suitable for upper Gangetic alluvial tract
West Bengal	WB No. 37	Oct.-Nov.	Feb.-Mar.	138	do.	480	40	A dual purpose strain yielding fibre and seed of high oil content
	WB No. 67	do.	do.	135	do.	720	39.8	Drought resistant

* *Improved Strains of Oilseeds maintained in different States in India and their characteristics*, Indian cent. Oilseeds Comm., 1958.
** Singh & Gangwar, *Indian Oilseeds J.*, 1958, **2**(4), 87; † Joglekar & Deshmukh, ibid., 1958, **2**(3), 10.

lines, the distance between rows ranges between 9 and 12 in. The seed rate for raising a pure crop is 20–30 lb./acre; when grown as *utera* or *paira* crop, the rate is 10 lb./acre.

Linseed is grown both as a pure as well as a mixed crop. As a mixed crop, it is sown either on the margins of fields or in rows alternating with the other crop. In Bihar, linseed is largely grown with wheat, gram, barley, pea or paddy. In Bombay State, a large proportion of the crop is sown mixed with jowar and occasionally with wheat and gram. In Madhya Pradesh and Rajasthan, the mixture is with wheat or gram. In Uttar Pradesh, linseed is sown mostly with wheat, barley, gram, jowar, rapeseed and mustard; nearly 80% of the total sown area in Uttar Pradesh is under mixed crop (Table 5). Since cattle, deer, wild pigs, etc. do not relish the linseed plant, sowing on margins provides protection to other crops. Sowing linseed with a leguminous crop, like gram or pea, helps to conserve the fertility of the soil and mixed sowing provides a sort of insurance against weather hazards (Dutt & Pugh, 276; Yegna Narayan Aiyer, *Indian J. agric. Sci.*, 1949, **19**, 502).

The bulk of linseed is raised as a rainfed crop in India; only in restricted areas of Bihar, Uttar Pradesh, Rajasthan and Punjab, the crop is irrigated. In trials carried out at Kanpur (U.P.), it was found that irrigation enhances the yield of seed (Stewart, *Rep. Soil Fertility Investigation in India*, Indian Coun. agric. Res., 1947, 146).

TABLE 5—AREA UNDER PURE AND MIXED SOWING OF LINSEED IN UTTAR PRADESH

	Area (thousand acres): Pure	Mixed	Total
1951–52	112	632	744
1952–53	119	665	784
1953–54	146	742	888
1954–55	127	712	839
1955–56	156	725	881
1956–57	186	651	837
1957–58	87	677	764
1958–59	203	690	893
1959–60	178	669	847

Application of nitrogenous fertilizers has a beneficial effect on yield. In trials conducted at the Indian Agricultural Research Institute, New Delhi, with a rust resistant strain *R.R. 9*, it was found that on an average, 40 lb. of nitrogen gave an increase of 8.11 md. seed per acre, response with ammonium sulphate nitrate ranking highest, followed closely by ammonium sulphate, calcium ammonium nitrate and urea. Trials under rainfed conditions in the hilly tracts of Uttar Pradesh with *K-2* type showed that nitrogen at 16 and 32 lb. per acre applied as ammonium sulphate gave an increased yield of 1.28 and 2.16 md.

per acre respectively; dosage higher than 32 lb./acre was not remunerative [Howard & Khan, loc. cit.; Stewart, loc. cit.; Mathur, *Indian Fmg, N.S.*, 1959–60, **9**(9), 18; Negi & Kingra, *Indian Oilseeds J.*, 1959, **3**(3), 162].

Diseases & Pests—Rust and wilt are the two serious diseases of linseed crop in India. Rust is caused by *Melampsora lini* (Ehrenb.) Lev. and in some localities, the attack is so severe that the crop is not worth harvesting. The disease makes its appearance as bright, yellow or orange coloured pustules on leaves, stems and floral parts. The pustules contain innumerable uredospores, which get readily dispersed by wind. There are nearly 40 physiological races of rust affecting linseed types in various countries, and new races arise by hybridization. Five physiological races of *Melampsora lini* have been established in India. Some of the American and Australian flax types are immune and a large number of resistant strains have been evolved as a result of crossing between Australian and Pusa types, combining rust resistance and other desirable characters, such as early maturity, high yield, high oil content, white seededness, etc. [Butler, 324; Mundkur, 158; Brooks, 287; Prasad, *Indian Phytopath.*, 1948, **1**, 1; *Rep. agric. Res. Inst. Pusa*, 1955, 90; 1956, 90; Deshpande, *Indian J. Genet.*, 1950, **10**, 7; Deshpande & Jeswani, ibid., 1951, **11**, 196; 1954, **14**, 22; Merh & Kulkarni, *Indian Oilseeds J.*, 1956–57, **1**, 105; 1958, **2**(3), 13; Mathur *et al.*, ibid., 1956–57, **1**, 145].

Wilt caused by *Fusarium lini* Bolley is also widespread and the plant may be affected at any time during the growth period. Its incidence is favoured by high soil temperature. Several physiological races of the fungus are known. The organism is carried by soil and use of wilt-resistant strains is the only solution for raising good crops. Use of healthy seeds and burning of affected ones afford subsidiary measures of control (Brooks, 397; Deshpande & Jeswani, *Curr. Sci.*, 1955, **24**, 202; Singh *et al.*, loc. cit.; Merh & Kulkarni, loc. cit.).

Powdery mildew caused by *Erysiphe polyphaga* Hammerlund (syn. *Oidium lini* Skoric) and blight caused by *Alternaria lini* Dey are two other diseases of linseed. These are not particularly serious in India (Brooks, 132; Chona *et al.*, *Bull. Indian Coun. agric. Res.*, No. 81, 1958, 25).

The following insects have been reported to cause injury to linseed crops: leaf eating insects: *Diacrisia obliqua* Wlk., *Prodenia litura* F., *Plusia orichalcea* F., *Laphygma exigua* Hubn.; stem cutting insects: *Agrotis ypsilon* Rott.; flower eating insects: *Dasyneura lini* Barnes. The caterpillar of *Dasyneura lini* feeds upon the ovary when the crop is in bloom and prevents capsule formation. *Laphygma exigua* feeds generally on leaves; it damages also buds, flowers and fruits (*Mem. Dep. Agric. Madras*, No. 36, 1954, 1062).

Harvest & Yield—The crop is harvested in February and March before the capsules are dry. Plants are cut close to the ground with a sickle or uprooted by hand. They are allowed to dry in the field for a day or two, then threshed and seeds separated from chaff by winnowing.

The usual method of threshing by bullocks trodding over the plants, breaks the stems into small pieces rendering them unsuitable for the recovery of long fibres. It is considered advantageous to extract seeds from capsule-bearing parts by beating with sticks or wooden mallets or by hand-driven deseeding machines. The stems may be collected and separately treated for the extraction of fibres.

The yield of linseed in different States is given in Table 6. The yield is low as compared with the average of 440 lb./acre in U.S.A., 471 lb. in Argentina, 544 lb. in Uruguay, 560 lb. in Canada, and 861 lb. in Mexico. A large number of improved types, now being distributed in some States, have given yields as high as 1,500–1,600 lb./acre (Table 4) (*Indian Oilseeds Atlas*, Indian Oilseeds Comm., 1958, 62, Table 27).

TABLE 6—AVERAGE YIELD OF LINSEED IN DIFFERENT STATES*
(lb./acre)

	1956 57	1957 58	1958 59	1959 60
Uttar Pradesh	297	233	396	378
Rajasthan	262	187	206	188
Jammu & Kashmir	448	487	..	..
Orissa	192	192	192	..
Bihar	139	177	237	221
West Bengal	148	243	259	166
Bombay	204	197	211	200
Madhya Pradesh	170	116	203	215
Mysore	142	168	..	..
Punjab	154	166	166	..
Andhra Pradesh	151	144	..	..

*Information from Dep. Econ. & Statist., Ministry of Food & Agriculture, Govt. India.

Storage—Linseed is stored in gunny bags, each holding 2–2¼ md. Stored seed is not subject to weevil attack and if adequately protected from moisture and dampness, it can be preserved for a considerable time without deterioration. Seeds stored in a hot humid atmosphere yield oil containing free fatty acids: the oil expressed from seeds stored in a damp atmosphere is dark in colour (*Agric. Marketing India, Rep. Marketing Linseed, Marketing Ser.*, No. 89, 1956, 111).

Utilization and Composition

The bulk of linseed produced in India is utilized for the expression of oil; only a small part is used for sowing, feeding and miscellaneous purposes. The consumption of linseed for various purposes during the triennium 1953–54 to 1955–56 was as follows: extraction of oil, 87.9; sowing, 5.0; stock feeding, medicinal and other purposes, 7.1%.

Linseed (size, 4–7 mm.; wt., 3.5–11 mg./seed) has a mild odour and a mucilaginous oily taste. In the eastern parts of U.P. and in Punjab it is used in the preparation of a kind of sweet, locally known as *pini*. In Madhya Pradesh and Bombay it is used in chutneys. Linseed is used as a nutritive feed for livestock. Feeding trials on cattle have shown that ground linseed is entirely satisfactory as a protein supplement. It contains: total digestible nutrients, 108.8%; digestible proteins, 14.8%; nutritive ratio, 6.6. It is, however, not much relished by animals and is fed only to a limited extent after crushing and boiling in water. It is mixed in cattle rations to act as a conditioner and is also given to race horses and polo ponies. Excessive feeding of linseed to pigs is liable to produce soft pork (Morrison, 485; *Rep. Marketing Linseed*, 1956, 31; Lander, 184, appx I).

Linseed is official in the Indian pharmacopoeia. It is demulcent, emollient, expectorant and diuretic; it is astringent after roasting. The whole seed is prescribed as a laxative in the same manner as ispaghula (*Plantago ovata* Forsk.). The mucilaginous infusion, linseed tea as it is called, is used internally as a demulcent in colds, coughs and bronchial affections, inflammation of the urinary tract, gonorrhoea and diarrhoea. The mucilage is dropped into the eye in irritable conditions of conjunctiva. Crushed linseed is applied in the form of a poultice for the relief of local inflammations and ulcers, boils and carbuncle; linseed poultice retains heat better than most substitutes and acts as a suppurative. Linseed poultice is also useful in bronchitis and other deep-seated inflammations and has been recommended for gouty and rheumatic swellings (I.P., 368–69; Nadkarni, I, 744–45; Wallis, 215; U.S.D., 1955, 758; Wren, 211; *Chem. Abstr.*, 1947, **41,** 2535).

In veterinary practice, linseed infusion is used as a demulcent drink for horses, cattle and occasionally, for small animals. Crushed linseed is used as a poultice; the surface of the poultice may be smeared with oil to prevent its adhering to the skin (B.V.C., 199–200).

Linseed oil is by far the most important commercial product derived from the seed. It is highly valued as a drying oil and extensively used in the paint and varnish industry and in the manufacture of linoleum.

Linseed cake obtained after the extraction of oil is highly valued as a protein supplement for livestock. The mucilage extracted from linseed or linseed cake is used in cosmetic and pharmaceutical industries. Linseed straw yields a fibre which is somewhat inferior to flax in quality. The fibre is used as such or after cottonization.

Linseed-boll chaff serves as a good roughage for cattle and horses. It is a fair source of protein but like oat straw, it is deficient in other nutrients. Leaves, cortical tissue of stem and linseed bolls may be used as a low-grade feed for cattle and sheep: the mixture is a good absorbent for molasses (Morrison, 381, 489; *Agric. Newslett., Aust.*, AGN/380, 1952, 1).

Chemical composition—Analysis of a sample of Indian linseed gave the following values: moisture, 6.6; protein, 20.3; fatty oil, 37.1; carbohydrates, 28.8; fibre, 4.8; mineral matter, 2.4; calcium, 0.17; and phosphorus, 0.37%; iron, 2.7 mg./100 g.; the seeds contain: carotene (as vitamin A, 50 i.u./100 g.), thiamine, riboflavin, niacin, pantothenic acid, choline (0.91–1.18 mg./g. as choline chloride) and vitamin E (4.7 mg./100 g.). Linseed required for medicinal use should contain: foreign organic matter, $\ngtr$ 1.0; fixed oil, $\nless$ 25.0; ash, $\ngtr$5.0; and water soluble extract, $\nless$ 15.0% (*Hlth Bull.*, No. 23, 1951, 42; Morrison, 1108; *Chem. Abstr.*, 1945, **39,** 2342; Brown, *J. Sci. Fd Agric.*, 1953, **4,** 161; I.P., 368–69).

The oil content of seed varies according to the type of linseed grown and the climatic conditions under which the crop has been raised. Bold seeds generally contain more oil than small seeds (Table 7). Drought and high temperature during

TABLE 7—OIL CONTENT OF LINSEED *

Size & colour of seed	Oil content %
Bold yellow	41.85–42.69
Bold fawn	43.31–44.76
Bold brown	42.32–44.36
Medium brown	38.91–39.38
Small brown	35.12–40.07

* Howard & Khan, *Mem. Dep. Agric. India, Bot.*, 1922–24, **12**, 180.

TABLE 8—CHANGES IN OIL CONTENT AND IODINE VALUE WITH THE DEVELOPMENT OF LINSEED *

Days after flowering	Oil content %	Iod. val.
10	2.5	114
14	15.1	119
17	31.1	127
23	37.0	143
28	36.9	170
35	36.8	180
51	36.3	190

* Hilditch, 1956, 441.

the seed-filling period reduce the oil content of the seeds. The oil content and the iodine value of oil vary with the maturity of seed (Table 8). Small-seeded varieties generally yield oil of higher iodine value than large-seeded ones. It has been observed that oils from the same type of linseed grown in widely different climatic conditions show large variations in iodine value. Linseed grown in cooler regions yields an oil of higher iodine value than that grown in warm climates. The mean temperature during the period of seed development influences the iodine value of the oil; also moisture deficiency during the period of seed ripening depresses the iodine value [Bailey, 1951, 169–70; Eckey, 534–35; *Oils & Oilseeds J.*, 1953–54, **6**(8), 16].

Crude linseed oil yields 0.25% phosphatides consisting of lecithin and cephalin. The component fatty acids of the total phosphatides are as follows: palmitic, 11; stearic, 11; hexadecenoic, 4; oleic, 34; linoleic, 20; linolenic, 17: and unsaturated C_{20-22}, 3% (Wittcoff, 483; Hilditch, 1956, 253–54).

Crude linseed oil contains a small amount of crystalline wax with the following characteristics: m.p. 76.6°; sp. gr. $^{14.1°}$, 0.977; $n^{80°}_{D}$, 1.4437; iod. val. (Hubl-Waller), 10.6; sap. val., 80.9; R.M. val., 0.09; Polenske val., 0.05; acid. val., 0; acet. val., 6.3; and unsapon. matter (ceryl alcohol), 43.14%. The wax contains: stearic acid, 18.7; cerotic acid, 32.5; ceryl alcohol, 43.1; and hydrocarbons, 7.0%; ceryl cerotate is the principal constituent (Warth, 301).

A water-soluble resinous matter with antioxidant properties has been isolated from crude linseed oil. It accompanies sterols in the unsaponifiable fraction and accounts for the induction period observed in the drying of raw oil films (Thorpe, VII, 324; IX, 26).

The protein content of linseed varies from 16 to 31%. The principal proteins of linseed are the globulins: two globulins have been isolated, viz. linin (N, 17.0%; S, 0.6%) and colinin (N, 16.7–17.0%; S, 0.72–0.79%). Linseed also contains a glutelin, but albumin appears to be absent. The non-protein nitrogen in the seed forms 21.7% of the total nitrogen; soluble nitrogen compounds include proteoses and peptones. Linseed proteoses resemble cottonseed proteoses and possess similar allergenic and antigenic properties; they contain relatively high proportions of arginine and glutamic acid (Winton & Winton, I, 531–32; Vassel & Nesbitt, *J. biol. Chem.*, 1945, **159,** 571; Smith *et al.*, *Industr. Engng Chem.*, 1946, **38,** 353; *Chem. Abstr.*, 1947, **41,** 1280; 1952, **46,** 1523).

The essential amino acids present in the total proteins of linseed are (expressed as g./16g.N): arginine, 8.4; histidine, 1.5; lysine, 2.5; tryptophan, 1.5; phenylalanine, 5.6; methionine, 2.3; threonine, 5.1; leucine, 7.0; *iso*leucine, 4.0; and valine, 7.0. Lysine is the principal limiting amino acid. Linseed proteins possess high digestibility co-efficient (89.6% at 8% level of protein intake) and biological value (77.4%) (Kuppuswamy *et al.*, 81, 87, 90).

The carbohydrates present in linseed are mostly sugars (sucrose and raffinose), cellulose and mucilage. Reducing sugars and starch do not occur in ripe seed although they are present in appreciable amounts before maturation. Linseeds contain 2–7% mucilage which is concentrated in the hulls; small seeds yield more mucilage than bold ones. Linseed mucilage is essentially the calcium salt of a polysaccharide acid, linseed acid, containing D-xylose, L-galactose, L-rhamnose, L-arabinose and D-galacturonic acid, together with a sugar which may be either ribose or fucose. Linseed also contains pectin which can be obtained (in 10% yield) from defatted

seed by extraction with dilute (0.01 N) hydrochloric acid. The jelly-forming power of the pectin is equal to that of apple pectin, but it imparts a slight dark colour to the jelly (Altschul, 608–09; U.S.D., 1955, 758; Wallis, 215: Smith & Montgomery, 356; *Chem. Abstr.*, 1954, **48,** 5297; 1951, **45,** 5843).

Linseed contains a cyanogenetic glucoside, linamarin (acetone-cyanohydrin-β-glucoside, $C_{10}H_{17}O_6N$, m.p. 142–43°) in small amounts; an enzyme, linase, which acts on the glucoside (opt. temp., 40–50°; opt. *p*H, 5) releasing hydrocyanic acid, is also present in the seed. The concentration of linamarin varies with the variety, maturity and oil content of the seed; seeds from fibre yielding types contain a higher percentage of glucoside than those from types grown for seed; ripe seeds contain less glucoside than immature seeds. Besides linamarin, linseed contains a crystalline glucoside (m.p. 167°, $[\alpha]^{27°}_{D}$, −73°) and a non-crystalline glucoside ($[\alpha]^{21°}_{D}$, −30°); the latter on hydrolysis yields glucose, β-hydroxy-β-methyl glutaric acid and an unidentified organic acid (McIlroy, 22; Altschul, 609; Chopra *et al.*, 250; *Chem. Abstr.*, 1955, **49,** 3831).

The cyanogenetic glucoside, linamarin, is present also in the leaves, stems, roots, and flowers of the plant and several cases of death among livestock due to grazing on linseed plant have been reported. Analysis of different plant parts for hydrocyanic acid (released mainly by the hydrolysis of linamarin) gave the following values: leaves, traces; stem tops after removal of flowers, 0.128; flowers (before fertilization), 0.08; flowers (after fertilization) with immature seeds, 0.692; mature seed, 0.06; husk, 0.046; and root, 0.067% (Chopra *et al.*, 250–52; Bagchi & Ganguli, *Indian J. vet. Sci.*, 1939, **9,** 61).

Other constituents reported to be present in linseed are: phytin (6.4% on defatted material), lecithin (0.88% on whole seed), wax, resin, pigments, malic acid, acetic acid (?) and the enzymes lipase, protease and diastase. The concentration of pigments decreases on ageing and storage. β-Carotene forms 22–30% of the total carotenoids. A yellow flavin-like pigment has been isolated (Bolley & McCormack, *J. Amer. Oil Chem. Soc.*, 1952, **29,** 470; U.S.D., 1955, 758; Wehmer, I, 594; *Chem. Abstr.*, 1936, **30,** 1592; 1935, **29,** 2576).

The constituents of linseed (ash content, 3.69%) ash are the following: potassium (K_2O), 30.63; sodium (Na_2O), 2.07; calcium (CaO), 8.10; magnesium (MgO), 14.29; iron (Fe_2O_3), 1.12; phosphorus (P_2O_5), 41.50; sulphur (SO_3), 2.34; chlorine, 0.16; and silica, 1.24%; *trace elements*: barium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, silver, strontium, tin, titanium, vanadium, zinc, lithium and arsenic (Winton & Winton, I, 535; Chamberlain, *E. Afr. agric. J.*, 1955–56, **21,** 103; Wehmer, I, 594).

The hulls are tough and fibrous and constitute *c.* 41% of the seed. Analysis of hulls gave the following values: moisture, 7.89; nitrogen, 3.18; oil, 1.84; and ash, 2.99%. They are rich in mucilage and pigments (Smith *et al.*, *Industr. Engng Chem.*, 1946, **38,** 353).

Linseed Products

LINSEED OIL

Linseed produced in India is utilized mainly (*c.* 88%) for the expression of oil. Both bullock-driven *ghanis* (capacity, 10–80 lb./day) and power driven rotary mills, expellers and hydraulic presses are used for this purpose. *Ghani* oil is reported to possess a sweet taste with pleasant flavour and is preferred for edible purposes. The yield of oil is 28–30% on the weight of seeds; efforts are being made by the All-India Village Industries Board to popularize an improved type of *ghani*, known as Wardha or Maganwadi *ghani*, which gives a higher yield of oil.

The bulk of commercial linseed oil is produced by the use of expellers. Before crushing, the seed is rolled into meal and heated after moistening, in a steam-jacketed trough fitted over the expeller. Hydraulic presses, particularly the open type Anglo-American press, are also in use; prior to pressing, the seed is ground and heated in a steam-jacketed kettle. Screw presses and solvent extraction plants are rarely employed for the extraction of oil in India (*Rep. Marketing Linseed*, 1956, 135–37, 140).

The oil yields from different types of linseed crushed by expellers are as follows (av. values): Bombay bold, 36; Calcutta bold, 34; and Calcutta small, 32%. The yield of oil from the same type of linseed varies with the machinery employed for pressing out the oil. Thus the yields of oil from Bombay bold, using expellers, hydraulic presses, and rotary mills, are respectively 35–36%, 34–35% and 32–33%. The All-India average for yield of oil from linseed is reported to be 33.3% (*Rep. Marketing Linseed*, 1956, 138).

Refining—Crude linseed oil contains free fatty acids, colouring matter and 'mucilaginous' matter. The proportion of these impurities in the oil depends

upon the conditions under which the seeds used for oil extraction have been stored and the methods employed for the extraction of oil. The mucilaginous impurity, break as it is called, consists mainly of phosphatides and carbohydrates; it contains also mineral matter, particularly salts of calcium, phosphorus and magnesium.

Linseed oil is refined by tanking for long periods, or by alkali or acid treatment. Filtration of oil followed by tanking results in the separation of a part of the mucilage. Treatment with alkali (10% caustic soda) yields a clear, pale yellow oil; free fatty acids react with caustic soda and the soap formed carries down the mucilaginous matter and a part of the colouring matter while settling; the neutralized oil is then washed with water. Treatment with sulphuric acid (1–2% on the wt. of oil) precipitates the mucilaginous matter; the acid is subsequently removed by washing with water. Acid-refined oils usually contain appreciable amounts of free fatty acids.

The break may be coagulated by rapidly heating the oil to 260° or above; coagulation is facilitated by the addition of small quantities of salt in aqueous solution. Heating may be effected by superheated steam.

The colour of refined oil is improved by treatment with decolourizing agents, such as Fullers' earth or activated carbon, at elevated temperatures (80–90°) and filtering through a press. The refined oil is chilled or wintered to separate any wax that may be present (Jamieson, 266-67, 271; Eckey, 544–45; Hilditch, 1943, 476–77; Heaton, 221; Thorpe, IV, 87–88).

Characteristics—Cold-pressed oil has a golden yellow colour, while oil obtained by hot-pressing is somewhat turbid and yellowish brown. Fresh refined oil is pale yellow with a mild odour and pleasant taste. The oil keeps well if stored in non-metallic containers unexposed to air and light. When exposed to air, the oil, especially refined oil which has been freed from natural anti-oxidants deteriorates in colour and develops an odour. Commercial oil is usually dark in colour with a rather disagreeable odour and an acrid taste. Among the linseed oils met with in the trade the Indian oil is the palest; Argentinian oil is somewhat darker; while Baltic and Canadian oils are the darkest (Encyclopaedia Britannica, XIV, 167; Heaton, 222; Chatfield, 5).

The constants of linseed oil produced in various countries fall within the following ranges: sp. gr.$^{20°}$, 0.927–0.931, sp. gr.$^{15°}$, 0.931–0.938; $n_D^{15°}$, 1.4808–1.4859, $n_D^{25°}$, 1.4786–1.4815, $n_D^{40°}$, 1.4742–1.4754; sap. val., 189–196; iod. val., 170–204; thiocyanogen val., 114.0–124.3; acet. val., 4.0–10.0; hexabromide val., 45.0–52.0; unsapon. matter, 0.5–1.6%; saturated acids, 8–12.5%; titre of fatty acids, 19–21°. The content of free fatty acids in the oil is usually below 5%. The unsaponifiable matter contains considerable quantities of sterols; tocopherol and squalene are present (Jamieson, 270; Williams, K. A., 309–10; Eckey, 544; Dickhart, *Amer. J. Pharm.*, 1955, **127**, 359).

The fatty acid composition of linseed oil from different sources varies within the following limits: total saturated (mainly palmitic and stearic), 6–16; oleic, 13–36; linoleic, 10–25; and linolenic, 30–60%. Oils from cooler climates are rich in linolenic acid. Analysis of Indian linseed oil (iod. val., 182.0) gave the following fatty acid composition: palmitic, 8.2; stearic, 6.8; arachidic, 0.5; oleic, 13.9; linoleic, 14.4; and linolenic, 56.2%. The oil had the following glyceride composition (% mol.): (*i*) disaturated, 3; monosaturated, 41; triunsaturated, 56; (*ii*) mono-linoleo-, 43; (*iii*) mono-linoleno-, 35; di-linoleno-, 59; trilinoleno, 5; (*iv*) mono-polyethenoid, 18; di-polyethenoid, 53; tri-polyethenoid, 29; (*v*) di+tri-polyethenoid, 82 (Hilditch, 1956, 173, 376; Hilditch *et al.*, *J. Sci. Fd Agric.*, 1951, **2**, 543).

Linseed oil with iodine value of 190 or above is considered to be of very good quality. Table 9 gives the limits of iodine value of oils from different countries. Baltic oil due to its high iodine value is generally considered to be the best; Indian linseed freed of impurities before crushing, yields oil of equally good quality (Brady, 467; Thorpe, VII, 320-21).

The iodine value of linseed oil is 160–200, which is the highest of all fats. A film of linseed oil when

TABLE 9—IODINE VALUE OF LINSEED OILS FROM DIFFERENT COUNTRIES*

Source	Iod. val. (Wijs)
Baltic (North Russia)	190–204
India	180–189
Canada†	177–188
Argentina (La Plata)	175–186
Black Sea (South Russia)	176–182
North America	177–188
Morocco, Holland, Turkey	185–202

*Jamieson, 270; †Chatfield, 5.

TABLE 10—FILM PROPERTIES OF SOME COMMERCIAL DRYING OILS *

Oil	Drying rate	Film texture	Resistance to Yellowing	Resistance to Water
Tung	Very fast	Hard, fair flexibility	Fair	Excellent
Oiticica	Fast	Hard, poor flexibility	Poor	Good
Dehydrated castor	Fairly fast	Medium hard, good flexibility	Very good	Good
Linseed	Medium	Slightly soft, flexible	Fair	Fair
Soybean	Slow	Soft, tacky, flexible	Good	Poor

* Kirk & Othmer, V, 295.

exposed to air gradually thickens due to oxidation, then gels and finally dries to an elastic coherent film with a distinct gloss. Drying is accelerated by the addition of oil-soluble salts of certain multivalent metals, such as linoleates and resinates of cobalt, manganese and lead. When heated to 200° or above, the oil polymerizes to a highly viscous mass (Jamieson, 271–72; Eckey, 535–36).

Uses Linseed oil is primarily an industrial oil used in the manufacture of paints and varnishes. It is by far the most important drying oil and its consumption exceeds all other drying oils combined. Linseed oil is taken as a standard for the evaluation of drying properties of other oils. The film properties of linseed and other drying oils are summarized in Table 10 (Jordan *et al.*, 52; Eckey, 546; Carrick, *J. Amer. Oil Chem. Soc.*, 1950, **27**, 514).

Linseed oil is used in the manufacture of linoleum and oil-cloth, printing and lithographic inks and soft soap. Relatively small amounts are employed in core oils, linings and packings, oil modified alkyd resins, caulking compounds, putties, leather finishing compounds, lubricants and greases, polishes, plasticizers and pyrotechnic compositions; it is used as a solvent for industrial stains and for seasoning bobbins (in jute textiles) and cricket bats and other sports goods. Linseed oil fatty acids find use in protective coatings and emulsifying agents (Eckey, 546; Kirk & Othmer, V, 296; XI, 323; XII, 728; *Rep. Marketing Linseed*, 1956, 145-47; Snell & Snell, 275).

Raw cold pressed oil is used to a considerable extent in eastern Europe, especially in U.S.S.R., for edible purposes. In India, *c.* 35% of the oil produced is so consumed particularly in Madhya Pradesh and in parts of Orissa, Bihar, U.P., Punjab, Jammu and Kashmir; in some localities, it is employed as an adulterant for mustard, groundnut and coconut oils. In 1953, when groundnut and other edible oils were in short supply, about 6,000 tons of linseed oil were reported to have been used for the manufacture of *Vanaspati*. Hydrogenated linseed oil was used for food purposes also in Canada during and immediately after World War II. Linseed oil, however, does not enjoy much favour for this purpose because of the rapid flavour reversion of processed products; furthermore, polymerization products formed on heat treatment are reported to be toxic (Eckey, 546; Thorpe, VII, 322; *Indian Oilseed Atlas*, Indian cent. Oilseeds Comm., 1958, Table 6; *Rep. Marketing Linseed*, 1956, 146–48; Wiseblatt *et al.*, *J. Sci. Fd Agric.*, 1953, **4**, 227; *J. Amer. Oil Chem. Soc.*, 1952, **29**, 639).

Linseed oil is official in some pharmacopoeias and is recommended mainly for external application. It is a common base for embrocations and liniments. Lotio Calcii Hydroxidi Oleosa, a mixture of equal volumes of linseed oil and calcium hydroxide solution, is a popular application for burns. A solution of linseed oil and sulphur was formerly used in the treatment of scabies and parasitic skin diseases. Linseed oil has laxative properties but is seldom employed as it is unpleasant to taste. It is sometimes given in enemas, especially in haemorrhoid cases. Boiled linseed oil which contains compounds of lead and other toxic elements, must not be prescribed for medicinal use (U.S.D., 1955, 759; I.P.C., 185, 328; Nadkarni, I, 745; Gutkin, *J. Amer. Oil Chem. Soc.*, 1950, **27**, 542).

In veterinary practice, linseed oil is employed as a laxative for horses and cattle. It is less liable to produce griping than castor oil and is used in such conditions as spasmodic colic, flatulent colic and impaction of colon. Linseed oil has to be dispensed with caution as large repeated doses may cause superpurgation; it may also cause laminitis in horses and affect the alimentary function in cattle. It is not suitable for small animals as it produces extreme nausea; it is sometimes administered as an enema. Linseed oil also finds use as a vehicle for irritating drugs, such as turpentine oil (B.V.C., 200; U.S.D., 1955, 1990).

Modified oils—The use of raw linseed oil in paint and related industries has a few drawbacks, e.g. slow drying rate, tendency to yellowing, continued oxidation after drying is apparently completed and poor colour retention. Processes have been developed to

improve linseed oil by heat modification, blending or by combining with suitable chemicals and adapt it to a variety of exacting demands of the protective coating industry.

Boiled Linseed Oils are obtained by heating the raw oil at 90–150° with driers, such as linoleates or resinates of lead, manganese, cobalt or zinc. The oil becomes viscous and the colour darkens. Boiled oil dries at a faster rate than raw oil and the film formed is smoother and more lustrous, and colour retention is improved. The grades of boiled linseed oil commercially available are: Extra Pale, Pale-boiled, Double-boiled, etc. Bung-hole Boiled Oil is made by churning refined linseed oil with a solution of organic driers without heating. It is a quick drying pale oil.

Boiled oils are used in the manufacture of paints but rarely employed in varnishes. They are also used in the manufacture of water-proof materials, patent leather and special finishes for cotton and silk fabrics.

Blown Linseed Oil is produced by blowing air through linseed oil at 130° for several hours till the desired viscosity is reached. Blown oil is golden yellow or reddish yellow in colour with high specific gravity and acid value. It has excellent drying and pigment wetting properties. It is used in the manufacture of linoleum and oil-cloth, and to some extent in interior paints and low grade enamels.

Stand Linseed Oil is obtained by heating alkali-refined linseed oil out of contact with air or in an atmosphere of inert gas at 290–300° till the desired consistency is obtained. The oil thickens by polymerization with little oxidation and is said to be "bodied". Stand oil is pale yellow in colour with honey-like consistency and high acid value (up to 22).

Stand oil gives an elastic film with improved durability and superior gloss. Thinner oils are widely used in enamels and varnishes while thicker oils (Litho oils) are employed in the manufacture of printing inks. Stand oil is also used as a vehicle for exterior paints and protective coatings for non-ferrous metals.

A process for the isomerization of linseed oil, developed at the H. B. Technological Institute, Kanpur, involves heating of the oil at 250° for ½ hr. in the presence of anthraquinone (5%) as catalyst in an inert atmosphere. The isomerized oil gives varnishes with excellent drying properties: films are resistant to water, acid and alkali.

Sulphurized Linseed Oil is prepared by stirring the oil with sulphur chloride or alternately, the oil is treated with flowers of sulphur at *c.* 100°. It is a thick brownish red liquid, which sets with extreme rapidity. It is used in the preparation of pigmented oil required for the so-called wet-on-wet process of painting in which several coats of the paint are applied at short intervals; the composite film is elastic and fairly durable. Sulphurized oil forms the base for many stoving finishes for rubber; it is also employed as an antiseptic.

Linseed oil treated with various chemicals is in demand for special applications. Styrenated linseed oil (Keltrol L) is prepared by reacting linseed oil with styrene; it dries to a hard, tough and alkali-resistant film. Esskol and Solinox are hydrogen-treated linseed oils used as substitutes for tung and castor oils. Solution of linseed oil in chlorinated hydrocarbons (e.g. ethylene dichloride) when treated with aluminium trichloride or boron trifluoride at elevated temperature (100°) yields polymerized products: silicon tetrachloride and titanic chloride have similar effect. Treatment of raw, polymerized or blown oil with solutions of phosphorus tri- or pentachloride in white spirit gives products with improved drying properties [Mistri, *Oils & Oilseeds J.*, 1952–53, **5**(10–12), 118; Carrick, *J. Amer. Oil Chem. Soc.* 1950, **27**, 514; Chatfield, 7–25; Hilditch, 1943, 477–83; Heaton, 223–27; Thorpe, IV, 88–91; *Res. & Ind.*, 1956, **1**, 237; Snell & Snell, 363; Brady, 468].

Large quantities of refined linseed oil were fractionated in U.S.A., during World War II, by the furfural process to yield Extract Oil with superior drying and bodying characteristics and used as a substitute for perilla oil; the saturated fraction or raffinate was used for alkyd manufacture (Jordan *et al.*, 108).

Linseed Oil Alkyds are produced by heating linseed oil with a polyol (usually glycerol) at 200–20° for an hour, followed by treatment with phthalic anhydride at higher temperatures (240–60°). Alkyds yield quick drying films with good gloss and outstanding durability and adhesion. They are used in exterior house paints, trim paints, exterior enamels, inks and coatings for silk fabrics. They find use in under-water primers because of their excellent adhesion (Moore, *J. Amer. Oil Chem. Soc.*, 1950, **27**, 510; Chatfield, 273, 286; Carrick, loc. cit.).

Substitutes—A general world shortage of linseed oil and a rising demand for improved oils required for special types of coatings have led to intensive research on linseed oil blends and substitutes. In many formulations, linseed oil has been completely replaced by blends of other drying oils.

Linseed oil can be blended with 10-15% of soybean oil with advantage; the mixture dries to a homogeneous elastic film. Addition of dehydrated castor oil (up to 50%) improves the drying properties of linseed oil and overcomes tackiness: the film of the blend retains the water resistance characteristics of castor oil films. Linseed oil may also be blended with tung oil in the ratio of 3 to 1 to yield a paint vehicle. It has been successfully blended with sesame, hempseed, sunflower, safflower, raisin seed, walnut, kamala seed, perilla, tobacco seed, poppy, nigerseed and fish oils in the preparation of paints for exterior applications (Chatfield, 25; Carrick, loc. cit.; Mistri, loc. cit.).

Adulterants—Linseed oil is sometimes adulterated, particularly when the market price is high, with vegetable oils, such as rape, cottonseed, soybean, sunflower, safflower and candlenut, as well as with rosin and mineral and fish oils. Boiled linseed oil is more frequently adulterated than raw oil. Adulteration is rather difficult to detect. Admixture of rape and mustard oils may be detected by the presence of erucic acid; the adulterants lower the saponification value. Fish oil may be detected by the odour produced on heating and by the melting point of ether-insoluble bromides. Rosin and mineral oils increase the proportion of unsaponifiable matter (Jamieson, 275–76; Thorpe, VII, 326; Pathak & Aggarwal, *J. sci. industr. Res.*, 1954, **13B**, 720).

TABLE 11—INDIAN SPECIFICATIONS FOR LINSEED OILS*

	Raw	Alkali or acid refined	Pale boiled	Boiled
Colour, Lovibond, 6.35 mm. cell (units)	≯35 (Y+10R)	≯10 (Y+10R)	≯10Y+2R	≯10Y+11R
Sp.gr.$^{30°}$	0.923–0.928	0.923–0.928	0.923–0.943	0.931–0.945
n_D	1.472–1.475	1.472–1.475	..	
Acid val.	≯4.0	Alkali refined, ≯0.5; acid refined, ≯6.0	≯6	≯8
Sap. val.	188–195	188–195	190–1	190–198
Iod. val.	≮175	≮175	..	..
Unsapon. matter (%)	≯1.5	≯1.5	≯2.0	≯2.5
Drying time	..	..	≯18 hr.	≯18 hr.
Ash content (%)	..	..	≯0.3	≯0.5

*IS: 75 1950; 76 1950; 77 1950; 78 1950.

Grades & Specifications—Various qualities of linseed oil are available in the Indian market; they include raw oil, alkali and acid refined oils, boiled oils, blown oils and stand oils; 'reduced' oils, prepared by mixing linseed oil with refined mineral oils or turpentine oil, are also marketed. The bulk of linseed oil is sold raw, after giving a simple clarifying treatment. According to the Prevention of Food Adulteration Rules, 1955 (amended in May 1959), linseed oil for edible purposes shall be free from rancidity and conform to the following standards: butyro-refractometer val. at 40°, 69.5–74.3; sap. val., 188–195; iod. val., ≮170; unsapon. matter, ≯1.5%; free fatty acids (as oleic), ≯2.0%. Linseed oil for industrial purposes should conform to the specifications of the Indian Standards Institution (Table 11); conformity with specifications laid down by the British Standards Institution is sometimes insisted on, by foreign consumers. The Agmark specifications provided for two grades of edible oil, viz. raw and alkali-refined, are the same as those prescribed by the Indian Standards Institution (*Rep. Marketing Linseed*, 1956, 140–42, 147–49).

LINSEED CAKE

Linseed cake obtained as a by product of the oil crushing industry is used mainly as a protein-rich feed for cattle. The oil content of the cake varies according to efficiency of the equipment employed for expelling the oil. Expeller cake contains 7–10% oil, while *ghani* cake contains up to 14% oil; the cake from hydraulic presses contains 9–12% oil (*Rep. Marketing Linseed*, 1956, 161–62, 137, 164).

Analysis of a sample of linseed cake (from Bengal) gave the following values: dry matter, 96.8; protein, 30.5; fat, 6.6; N-free extr., 43.2; crude fibre, 9.5; and mineral matter, 7.0%. It contains: total digestible nutrients, 77.2% and digestible protein, 25.9%; nutritive ratio, 1:1.8. Vitamins of the B group present in the cake are: thiamine, 0.57; riboflavin, 0.33; niacin, 4.06; and pantothenic acid, 1.21 mg./100 g.; a small amount of vitamin E is present. Linseed cake does not contain vitamins A, C and D. Linseed cake is a rich source of phosphorus and a fair source of calcium; it contains: calcium, 0.37; phosphorus, 0.86; potassium, 1.24; sodium, 0.11; chlorine, 0.04; sulphur, 0.38; magnesium, 0.58; and iron, 0.017%; manganese, 3.95; and copper, 2.65 mg./100 g. (Lander, appx I, IV; Morrison, 486, 1100, 1108).

TABLE 12—COMPARATIVE NUTRITIVE VALUES OF LINSEED AND OTHER OILSEED CAKES*

Cake	Protein %	Digestible protein %	Total digestible nutrients %	Nutritive Ratio %
Linseed (*Linum usitatissimum*)	30.5	25.9		1.8
Cottonseed (*Gossypium* sp., undecorticated)	21.1	18.0		3.1
Cottonseed (decorticated)	36.3	29.1	63.8	1.1
Groundnut (*Arachis hypogaea*)	48.7	43.8	74.1	0.7
Sarson (*Brassica campestris* var. *dichotoma*)	29.6	26.9	81.6	2.3
Sesame (*Sesamum indicum*)	43.5	38.3	94.0	1.1
Toria (*Brassica campestris* var. *toria*)	35.0	30.1	74.0	1.5

* Lander, appx I.

Linseed cake is highly esteemed as a feed-stuff for dairy cattle and young stock. It is valued for its conditioning, appetite-stimulating and slightly laxative effects; it resembles sesame cake in its sedative action on bowels. Cattle and horses required for show purposes are given supplements of linseed cake as it aids in giving a glossy coat and mellow skin. Linseed cake is generally used in concentrate mixtures and is particularly useful when succulents and legume hay are unavailable. It is considered somewhat superior to cottonseed cake for fattening cattle. Linseed cake has not proved useful in poultry feeding. The comparative nutritive values of linseed and other oilseed cakes commonly used in India as livestock feeds are given in Table 12 (Morrison, 485–89; Lander, 177–78; Ellis & Bird, *Yearb. Agric. U.S. Dep. Agric.*, 1950–51, 855; Daji, *Indian Fmg*, 1943, **4,** 553; *Agric. Newslett., Aust.*, AGN/380, 1952, 1).

Linseed and linseed cake or meal is occasionally reported to cause cyanide poisoning in livestock. The cyanogenetic glucoside, linamarin, present in the cake, is accompanied by the enzyme linase which under favourable conditions hydrolyses the glucoside into glucose, acetone and hydrocyanic acid. Analysis of cakes from different sources has shown that the quantity of hydrocyanic acid released varies from 0.032–0.045%; the toxicity of the cake is determined by the amount and rate of liberation of hydrocyanic acid in the stomach of the animals: hydrolysis of linamarin by linase is inhibited by gastric juices and under normal conditions, the chances of poisoning are remote. Hot-pressed cake is considered to be less toxic than cold-pressed cake as the enzyme is mostly inactivated during hot expression. To obviate any chance of poisoning, linseed and linseed cake should be boiled with water to inactivate the enzyme and use of immature seed should be totally avoided [U.S.D., 1955, 1989; Chopra *et al.*, 250–52; Allen, II, 451–53; Khan, *Oils & Oilseeds J.*, 1951–52, **4**(6), 6].

Linseed meal is reported to possess goitrogenic effect on sheep and mice. Ewes fed on diet containing linseed meal, under controlled conditions, have been observed to produce lambs with acute goitre. The goitrogenic principle has been identified as a thiocyanate; hydrolysis of linamarin in the rumen of sheep produces cyanide which is detoxicated by the liver in the form of thiocyanate. As a prophylactic, sheep are given iodinated water for drinking (Care, *Nature, Lond.*, 1954, **173,** 172; *N.Z.J. Sci. Technol.*, 1954–55, **36A,** 321).

Linseed cake is utilized to a limited extent as a manure: it contains (air-dry basis): nitrogen, 4.49–5.64; phosphorus (as P_2O_5), 0.95–1.63; and potash (K_2O), 1.15–1.63% (*Rep. Marketing Linseed*, 1956, 164; Subba Rao, *Indian Soap J.*, 1952–53, **18,** 90).

Linseed cake finds a few minor uses in industry. It is used as a source of mucilage and protein. Linseed meal is used as a filter aid in the processing of uranium and iron-copper sulphide and in the settling of cement slurry and kaolin clay. It may be blended with phenolic resins (ratio 4:6) for the preparation of plywood glues. A process has been patented for the use of linseed meal as a filler in thermosetting resins; it imparts improved water resistance. Linseed meal is also used as a corrosion inhibitor, as a binding material in water paints and for stabilizing mud plaster (Whistler & Smart, 328; Smith *et al.*, *Industr. Engng Chem.*, 1946, **38,** 353; Babcock & Smith, ibid., 1947, **39,** 85; Kirk & Othmer, XIV, 438; *Chem. Abstr.*, 1946, **40,** 2328, 499, 5001; 1939, **33,** 883; Lal & Dhawan, *J. Indian Rds Congr.*, 1955, **19,** 273).

LINSEED MUCILAGE

Linseed mucilage is prepared from aqueous extracts of the seed (soaking in water for 24 hr.) by precipitation. It is obtained as a white fibrous mass which becomes friable when completely dry. It

dissolves readily in water and gives solutions of high viscosity. Defatted linseed meal may be used with advantage in place of seeds for the extraction of mucilage (yield, 3–10%). In a patented process, solvent extracted linseed meal is separated into kernel and hull fractions and the mucilage extracted from the latter with dilute hydrochloric acid; the extract is concentrated by evaporation under reduced pressure and spray-dried (Whistler & Smart, 327–29; Altschul, 608; Hodge, *Econ. Bot.*, 1955, **9**, 99).

Linseed mucilage is used in cosmetic and pharmaceutical industries as a demulcent. It is recommended for use in food products as a water-soluble emulsifying agent, thickener or binder. It may be employed as a substitute of acacia gum in the stabilization of emulsions and is a useful base for eye ointments. It is also suitable for use in water paints and in the manufacture of soluble fibres (Whistler & Smart, 327; *Chem. Abstr.*, 1955, **49**, 11240; 1952, **46**, 9333).

FLAX & LINSEED FIBRE

Flax is extracted from the stalks of linum types specially grown for this purpose and harvested when the capsules are immature. Linseed fibre is obtained from types grown for seed purposes and extracted from straw after harvesting the seeds. Seeds obtained from type grown for fibre are poor in oil content, while fibre obtained from seed-bearing types are poor in quality. In parts of Europe, Canada and U.S.A., dual purpose types are also grown, but both seed and fibre obtained from them are of inferior quality (*Vegetable Oils and Oilseeds*, Commonwealth Econ. Comm., 1958, 145; Bunting, *World Crops*, 1951, **3**, 95).

Flax—India imports annually 400–500 tons of flax fibre, flax tow and waste, from Belgium, Holland, and occasionally Egypt. Several attempts have been made to cultivate fibre flax in India. Trials have been made in Bengal, Bihar, U.P., Punjab and Madhya Pradesh using both Indian types and acclimatized European material, from imported seeds. It was found that while plants grew well in selected areas, the seeds of imported types degenerated in 2 or 3 years and fresh seeds had to be imported. As seed requirements for fibre flax are higher than those for seed types, the cost of seed becomes a significant factor in the economics of flax production. It has been suggested that better results may be obtained if it is tried in areas with a temperate climate and sufficient soil moisture during winter and spring. The areas suggested are Kashmir, Kangra, Terrai in Kumaon and Dooars in Darjeeling. Meanwhile, about 18,000 acres are reported to be grown with fibre yielding types in Mysore State (Richharia, 264–65; Burt, *Agric. J. India*, 1920, **15**, 61; Sircar, *Misc. Bull. Indian Coun. agric. Res.*, No. 66, 1948, 34; Wlth India—Industrial Products, pt IV, 71–75).

Fibre types are generally grown in temperate regions; they require a cool, moist climate, somewhat cloudy during the growing period. They do well in moist, well drained soils, rich in organic matter. They are sown close together, either by broadcasting or by seed-sowing appliances and they mature in 70–100 days. In Bengal and Bihar, where fibre types have been tried, 3 or 4 irrigations are necessary during the dry period.

The crop is harvested before the capsules are mature. The stage for harvesting is reached when the lower part of the stalk turns yellow and bottom leaves begin to droop. In most places, harvesting is generally done by pulling the plants by roots; in U.S.S.R., U.S.A., Canada and a few other countries, mechanical appliances are also employed for pulling the plants.

Harvested stalks are partially or completely dried and seeds removed by rippling i.e. drawing the heads through a coarse comb. Deseeded stalks are then subjected to retting; the methods in use are: water retting, dew or grass retting, mixed retting, and snow retting. Water retting is by far the most common. Stalks are bundled together and immersed in water after weighting. The time required varies from 2 to 3 weeks, depending upon the temperature and softness of water. Fibres are separated from retted stock by scutching and drying.

The colour of raw fibre varies from creamy white to grey; badly stripped or over-retted fibre is dark brown or dirty grey-green in colour. Fibre strands range in length from 15–100 cm. (usually 37.5–62.5 cm.) and are made up of bundles of small elements cemented together by a gummy substance. The ultimate fibres have an average length of 25–30 mm. and an average diameter of 15–18 μ. They are round to polygonal in cross-section, more or less cylindrical in shape, with pointed ends, uniformly thick walls and narrow and irregular lumen; the surface is smooth, except for characteristic nodes or cross-markings. They do not exhibit convolutions as do cotton fibres (Weindling, 234; Matthews, 296–97; Harris, 68).

Flax fibre is valued for its outstanding strength, fineness and durability. It is stronger and more durable than cotton. It is soft, lustrous and flexible

and possesses high water absorbency. It has low elasticity and is stronger when wet than when dry. The tensile properties of the fibre are as follows: fineness, 17.81 Denier; tensile strength, 83.8 kg./sq. mm.; tenacity, 6.29 g./Denier; wet strength, 105.5% of dry; and ultimate elongation, 1.8% when dry, 2.2% when wet (Weindling, 234–35; Matthews, 295; Harris, 138).

Flax has good resistance to moisture and mildew. It takes crease-resistant and other special finishes well. The fibre does not react to mordants and dyes as readily as cotton but is less resistant to high temperatures. Fabrics made from it launder well; they feel noticeably colder to the touch than do cotton fibres (Matthews, 296; Hess, 329; Weindling, 235).

Flax usually contains 70–80% cellulose as compared to c. 90% in cotton. Other constituents present in flax are: fat and wax, 2–3; lignin and pectic bodies, 2–5; and ash, 1%. The gummy substance which binds the fibre cells into bundles, often called pectin, is a complex mixture of carbohydrates. The water extractable material contains at least two groups of complex polysaccharides, one of which can be precipitated from solution by ethyl alcohol. Flax contains 1–2% wax which imparts suppleness to the fibre (Weindling, 235; Harris, 57; Kirk & Othmer, VIII, 388; Matthews, 295).

Flax fibre is woven into fine fibrics, such as lawns, cambrics, hollands, crashes and damasks, and also into canvas, drills, ducks and buckrams. It is used for linen stitching, paulin stitching, fishing twines, binding twines, ropes, fishing nets, and other purposes where strength is a primary requirement. It is also used for carpet making, house furnishings, sails and wrapping cloth. Other items of linen manufactures include handkerchiefs, table and bed linens, dress interlinings, men's suitings, towels, tents, draperies, upholstery covers, surgical dressings, fire-fighting hoses and water-holding bags.

The dried cortical tissue separated from flax fibre contains c. 10% wax; flax dust from the spinning house contains c. 6%. The wax may be commercially extracted by organic solvents and used in shoe polishes; it may be used also as a substitute for beeswax (Warth, 201–02).

Linseed fibre—Deseeded stalks (or straw) from types grown for seeds are usually burnt as fuel or otherwise wasted; in certain parts of India, they are fed to cattle or used for thatching purposes. Linseed straw is comparable to oat straw in nutritive value; it should be freed from immature seeds before use.

Linseed straw can be processed to yield a fibre resembling flax. The process employed is as follows: the stalks are tied into bundles (up to 20 cm. diam.) and retted by steeping in water for 4 days or dipped in a dilute solution of caustic soda and cooked. Treated material is washed in water and dried in the sun. The fibre is then separated from the core by hand-operated fluted rollers or by power machines.

A dry-scutching process for the extraction of fibre has been patented; dried stalks (moisture content c. 9%) are pressed between fluted rollers or beaten by wooden mallets and the broken pith (shives) removed by a mechanical contrivance. The fibre is then worked through a wire comb for separating long fibres from short ones. Long fibres can be spun to fine yarn; short fibres give coarse yarn. The fibre properties can be improved by cottonizing (Richharia, 1950, 44–64, 82–111, 125–33; Athawale & Mulany, *Bull. Dep. Ind., U.P., N.S.*, No. 16, 1941, 3–7).

The average yield of dry straw is estimated at 820–1,250 lb./acre; and the yield of fibre on the weight of dry straw is 20–25%. Dry-scutching gives a higher yield of fibre than retting, but the quality is inferior.

TABLE 13—FIBRE AND OIL CONTENT OF LINSEED TYPES FROM DIFFERENT STATES*

Type	State	Colour & size of seed	Dry scutched fibre	Oil
Local (Nagpur)	Bombay	Brown, bold	21.0	41.0
O.S.X. (I.C.R.V.)	Bombay	Dull yellow, bold	20.3	47.0
E.B. 3 (I.C.R.I.)	Bombay	Brown, bold	18.7	39.0
No. 3255 (I.C.R.VI)	Bombay	Brown, bold	25.0	39.0
No. 1150 (Kanpur)	U.P.	Brown, medium	20.0	38.8
No. 1193	U.P.	Brown, bold	21.6	40.7
No. 483	U.P.	Brown, small	30.7	39.8
No. 1206	U.P.	Yellow, bold	17.4	43.1
B.R. 1	Bihar	Brown, medium	24.3	46.73
B.R. 2	Bihar	Brown, medium	17.4	43.74
S. 6	Bihar	Brown, medium	15.0	42.64

* Information from Dr. Richharia, Sabour.

Table 13 gives the percentage of dry-scutched fibre from linseed types grown in different States. Linseed straw yields on an average 6% long fibre and 20% short fibre (on the weight of dry stem). The latter can be separated into equal proportions of soft and hard fibre; soft fibre can be utilized for spinning and hard fibre for paper manufacture (Paul & Sarkar, *Jute Bull.*, 1950–51, **13**, 111; Richharia, 1950, 65, 76, 100; Athawale & Mulany, loc. cit.).

The quality of fibre obtained from linseed stalk depends upon a number of factors, including the time of sowing, seed rate, cultural treatment, stage of harvesting and process employed for extracting the fibre. Early sowing at high seed rates of good fibre-yielding types, followed by irrigation, favours the production of fibre of fine quality. Harvesting at a stage when capsules are turning brown but stems are still green helps in obtaining a soft and fairly long fibre: seed yield is not affected. The fibre separated by dry-scutching is coarse and weak, while that from retted straw is soft, long and lustrous; chemical retting gives better results than water retting. Straw damaged by rust or rains yields weak and dark coloured fibre (Richharia, 1950, 122–24, 100–01).

The colour of the fibre is golden yellow to yellowish white when extracted by dry-scutching and silver-grey or dirty grey when obtained from retted straw. The length of fibre varies with variety and ranges from 17.5 to 30 cm.; ultimate fibres are 20–30 mm. in length and 0.5–2.3 μ in diameter. Retted fibre contains: moisture, 9.0; α-cellulose + hemicellulose, 80.7; pectin, 3.1; lignin, 3.6; fat and wax, 2.4; water soluble extr., 2.1; and ash, 1.0% (Richharia, 1950, 123, 79–80; Biswas, *Indian Pulp Pap.*, 1959–60, **14**, 117).

Linseed fibre, though inferior to flax, is strong and can be put to a variety of uses. It may be spun as a textile, either by itself or in mixture with cotton, jute, wool and *tassar* silk. It is suitable for spinning on jute and cotton machinery after suitable adjustment. Linseed fibre may be used in the manufacture of twines, ropes and canvas; it was employed during World War II for making sewing cords for leather goods. It can be used as a partial substitute for jute in the manufacture of carpet backing and can be blended to a limited extent with jute in the production of sacking and hessian. It can also be used as a substitute for coir in matting.

Yarn spun from cottonized linseed fibre is suitable for rugs, blankets and *niwar* (used for beds). Cottonized fibre can be blended with cotton in various proportions; spun yarn from blends is stronger than cotton yarn of equivalent count. Suiting and shirting cloth, bed spreads, curtains, carpets, blankets and canvas have been produced from blended yarn (Richharia, 1950, 134–63; Athawale & Mulany, loc. cit.; *Jute Bull.*, 1949–50, **12**, 289; *Rep. Marketing Linseed*, 1956, 133–34).

Paper pulp—Linseed fibre is suitable for the manufacture of high grade paper pulp. As the lignin and pentosan contents of the fibre are low, the paper produced has good strength. Clean fibre, free from shives, gives bleached pulp in 64.6% yield (alkali consumption, 10%; cooking temp., 150°; chlorine consumption, 0.64%). Commercial fibre (tow) contains a certain amount of shives and the pulp obtained from it by the normal treatment is of inferior quality. A better pulp is produced (yield, 43%) by the sulphur-soda process involving digestion with 20–22% caustic soda + 3% sulphur for 5–6 hr. at 150–60° (Biswas, *Indian Pulp Pap.*, 1959–60, **14**, 117; Lathrop & Nelson, ibid., 1954–55, **9**, 27).

Linseed tow has replaced linen rags in the manufacture of cigarette, air-mail, bond, Bible and other high priced book and writing papers. It is used also in the manufacture of safety paper used for currency notes. Practically all cigarette paper produced in U.S.A. is from tow; in India, one firm in Howrah is reported to be using linseed fibre for a similar purpose (Aronovsky *et al.*, *Yearb. Agric. U. S. Dep. Agric.*, 1950–51, 837; Lathrop & Nelson, loc. cit.; *Rep. Marketing Linseed*, 1956, 133).

Linseed straw may be employed in the manufacture of building board, cardboard and wrapping and insulating material. In Argentina, the straw is processed into burlap. Digestion of straw with 10% lime (CaO) in a concentration of 16.6 g./litre at 162° for 4¾ hr. and kollerganging gives a pulp (in 59% yield) with satisfactory strength properties; the pulp is processed into wrapping paper (*Jute Bull.*, 1949–50, **12**, 289; Richharia, 1950, 159–60; Bunting, *World Crops*, 1951, **3**, 95; Bhat, *Indian Pulp Pap.*, 1954–55, **9**, 41).

The residue left after the extraction of fibre is used as fuel or as wall board stock, feed and bedding. Shives from unretted and retted straws contain respectively: cellulose, 46.15 and 48.9; lignin, 30.4 and 27.8; and pentosans, 26.5 and 22.0%; digestion with 10% caustic soda yields a low grade pulp suitable for the manufacture of cardboard. Attempts have been made to utilize shives, after grinding, in the manufacture of linoleum (*Econ. Bot.*, 1949, **3**, 359; *Rep.*

Comm. Util. Fd & agric. Wastes, Coun. sci. industr. Res., New Delhi, 1959, 66; Aronovsky *et al.*, loc. cit.; Richharia, 1950, 162, 167; *Jute Bull.*, 1949–50, **12**, 289).

Production and Trade

LINSEED

Prior to World War II, the major part of linseed produced in India was exported to foreign countries, particularly to U.S. At present the bulk is consumed in India for the expression of oil.

Inter-State trade—Considerable quantities of seed are moved by road between States and reliable data relating to such movements are not available. Information on movement of linseed by rail is summarized in Table 14.

Linseed is classified in the trade according to the colour and size of seeds. Brown types constitute the bulk; white and yellow types are produced in small quantities in Ujjain, Indore, Dewas, Dhar, Jabalpur and Hoshangabad districts of Madhya Pradesh, Nagpur and Chanda districts of Maharashtra and Kotah district of Rajasthan. Brown types are classified on the basis of size into Bold and Small; the former is further classified as Bombay Bold and Calcutta Bold. The number of individual seeds per gramme forms the basis for classification. Calcutta Bold comprises seeds 153 of which weigh 1 g. Category Small includes type in which the number of seeds per g. exceeds 153; category Bold comprises types in which the number of seeds per g. lies between 135 and 153. Small types are grown in Assam, West Bengal and north and north-eastern parts of Madhya Pradesh. Linseed produced in Rajasthan, Bombay, Mysore, Andhra Pradesh, south and western parts of Madhya Pradesh and Jhansi conforms to Bombay Bold grade (135–153 seeds/g.). Linseed grown in Varanasi, Allahabad and Mirzapur districts of Uttar Pradesh and Patna and Gaya districts of Bihar usually conforms to the standard of Calcutta Bold. Of the total linseed grown in India, *c.* 51% is Small linseed, 42% Bombay Bold and 7% Calcutta Bold. The production of white and yellow linseed, which is classified as Bombay Bold, forms only 0.1% of the total production (*Rep. Marketing Linseed*, 1956, 78).

Linseed is bought or sold by mills or exporting firms on refraction-free basis. The refraction present in commercial linseed may be oleaginous or non-oleaginous; damaged grains may also be present. Oleaginous impurities are usually rapeseed, mustard or *taramira*; these impurities are commonly met with

TABLE 14—INTER-STATE MOVEMENT OF LINSEED BY RAIL & RIVER†
(thousand metric tons)

	1954–55	1955–56	1956–57	1957–58	1958–59
From:					
Bihar	13.7*	24.9	20.5	7.3	14.0
Bombay	1.7	0.9	2.8	3.0	2.3
Uttar Pradesh	10.1*	14.3	8.8	5.1	7.2
Hyderabad	7.1	7.7	7.3	16.2	10.4
Rajasthan	0.1	4.4	4.2	8.9	2.5
Madhya Pradesh	9.6	9.1	3.8	2.3	1.2
Others	3.9*	19.7	15.3	26.4	16.4
Total	46.2	81.0	62.7	69.2	54.0
To:					
West Bengal (including Calcutta port)	20.1*	39.1	26.4	12.9	18.0
Bihar	1.2*	3.0	3.3	2.4	3.3
Uttar Pradesh	4.5*	7.9	8.8	18.1	7.8
Madhya Pradesh	9.1	12.8	7.6	9.6	14.5
Bombay (including Bombay port)	6.0	14.8	13.1	17.8	7.8
Others	5.3*	3.4	3.5	8.4	2.6
Total	46.2	81.0	62.7	69.2	54.0

†*Accounts relating to the Inland (rail and riverborne) Trade of India.* *Incomplete and subject to revision.

in linseed grown in Uttar Pradesh and Bihar, and are attributed to mixed sowings. Non-oleaginous impurities consist of stones, lumps of earth, straw or chaff and grains of wheat, gram, barley, jowar and pulses. These impurities find their way into linseed due partly to carelessness during threshing or in assembling markets and partly to mixed sowing. Generally, there are fewer impurities in linseed grown in northern parts of the country than in central and southern parts.

Seeds which have become wholly or partially discoloured either before or after harvesting, as also seeds not fully mature are regarded as damaged grains. The amount of damaged seeds varies in different localities and seasons; the proportion is relatively high in linseed crops grown in dry areas.

Imports—There is practically no import of linseed by sea. Small quantities are brought into India by land, mainly from Nepal, Tibet, Sikkim and Bhutan. Table 15 gives the imports of linseed from adjacent areas by land, at selected border stations.

TABLE 15—IMPORTS (BY LAND) OF LINSEED INTO INDIA*

	Qty (md.)
1955-56	40,769
1956-57	70,262
1957-58	136,297
1958-59	103,137
1959-60	124,304

*Information from Department, Commercial Intelligence & Statistics, Govt. India.

Exports—Linseed had an important place in the export trade of India prior to World War II; export of linseed has practically ceased since 1952. United Kingdom used to be the single largest importer, followed by Australia, Netherlands, New Zealand, France, Italy and U.S.A.

Prices—Bold linseed usually commands a premium over Small linseed, both at Bombay and Calcutta. The premium obtained, however, varies according to supply and demand. An idea of the premium obtained by Bold linseed over Small at Bombay and Calcutta can be had from Table 16.

LINSEED OIL

The average annual production of linseed oil in India during the triennium 1950-51 to 1952-53 amounted to 103,000 tons obtained from 271,000 tons of linseed crushed by power mills and 38,000 tons by *ghani*. Under conditions of commercial production, 3 tons of linseed yield approximately 1 ton of oil and 2 tons of cake. The estimated quantities of linseed crushed annually (av. of 1950-51 to 1952-53) by power mills and village *ghanis* in different parts of the country are given in Table 17.

Imports—With the development of the oilseed crushing industry in the country, imports of linseed oil have progressively declined. The imports during the quinquennium 1951-52 to 1955-56 averaged less than 3 tons of boiled linseed oil per year as compared with the average import of 809 tons during the quinquennium 1933-34 to 1937-38. There is no import of raw linseed oil.

Exports—Export of linseed oil from India, during the post-war years has varied considerably from year

TABLE 16—AVERAGE WHOLESALE PRICES OF BOLD AND SMALL LINSEED AT BOMBAY AND CALCUTTA*
(Rs. per maund)

	Bombay Bold	Bombay Small	Pre[illegible] for Bo[illegible]	Calcutta Bold	Calcutta Small	Premium for Bold over Small
	Rs.	Rs.	%	Rs.	Rs.	%
1952-53	20.70	19.24	7.6	20.27	19.77	2.6
1953-54	20.88	19.25	8.5	22.54	20.62	9.3
1954-55	17.37	16.01	8.5	n.a.	17.25	..
1955-56	19.40	18.23	6.4	n.a.	19.69	..
1956-57	23.43	21.37	8.7	n.a.	20.43	
1957-58	21.54	20.43	5.1	n.a.	16.56	..
1958-59	24.48	..			25.62	..
1959-60	24.62	..			24.01	..

* Prices relate to the year April-March. n.a. not available.

TABLE 17—QUANTITIES OF LINSEED CRUSHED BY POWER MILLS AND GHANIS IN DIFFERENT STATES*
(av., 1950–51 to 1952–53)

States	Qty in 1,000 tons		
	By power mills	By ghanis	Total
Madhya Pradesh†	83.0	10.8	93.8
Uttar Pradesh	60.0	14.0	74.0
West Bengal	50.0	..	50.0
Bihar	30.0	4.0	34.0
Bombay	24.0	..	24.0
Rajasthan	12.0	3.4	15.4
Jammu & Kashmir	3.0	1.5	4.5
Orissa	..	3.7	3.7
Punjab	2.5	0.6	3.1
Others	6.7		6.7

*Rep. Marketing Linseed, 1956, 39, 139, 210. †Including Vidharba, now merged with Bombay.

TABLE 18—EXPORTS OF LINSEED OIL FROM INDIA
(Qty in tons and value in thousand Rs.)

	Qty				Total	
	U.K.	Australia	Rumania	Others	Qty	Val.
1957	8,037	5,386	568	1,234	15,225	16,618
1958	11,242	8,859	615	4,012	21,727	30,303
1959 (a)	11,710	5,839	683	542	18,771	26,608
(b)	..	230	..	585	815	1,307
1960* (a)	4,284	417	1,077	904	6,682	8,763
(b)				531	531	953

(a) Crude, refined or purified oil; (b) oxidized, blown or boiled oil.
* Data for period Apr. 1960–Mar. 1961.

to year depending upon the price of linseed oil in world markets. The highest export (77,068 tons) was in 1955–56. The quantities of linseed oil exported from India are given in Table 18.

Before World War II, Burma was the principal importer of Indian linseed oil followed by Straits Settlements. During the war, the Union of South Africa became the largest importer followed by New Zealand in some years and Egypt in others. In recent years United Kingdom, Australia and Rumania have accounted for substantial off-takes of oil from India.

Prices.—The average annual wholesale prices of raw linseed oil at Bombay, Calcutta, Kanpur and Nagpur are given in Table 19. The prices at Bombay and Calcutta generally move in sympathy. Nagpur prices are at times higher than those prevailing at other centres, because of the demand for edible oil.

LINSEED CAKE

Prior to World War II, the bulk of linseed cake from power mills was exported, while that produced by village *ghanis* was used in the country. In 1944, the Government of India imposed a ban on the export of oil cakes, including linseed cake, with a view to utilize them within the country. Since February 1955, export of linseed cake in limited quantities is permitted. The quantity of cake exported during 1957 and 1958 amounted to 1,048 tons and 6,115 tons respectively; in 1959, the total amount of cake exported rose to 71,556 tons valued at nearly 2.92 crores of rupees. The export in 1957 and 1958 was only to U.K.; in 1959 the importing countries were: U.K., 23,006; West Germany, 12,468; France, 9,649; Netherlands, 9,221; Belgium, 8,249; Poland, 5,859; and others, 3,104 tons. Linseed cake for export should

TABLE 19—AVERAGE ANNUAL PRICES OF LINSEED OIL
(Rs. per maund)

Year	Bombay	Calcutta	Kanpur	Nagpur
1949–50	57.66	59.44	56.92	58.56
1950–51	66.07	68.21	66.22	65.29
1951–52	65.33	65.77	62.78	64.56
1952–53	46.46	45.81	43.48	46.84
1953–54	45.40	47.49	45.51	47.79
1954–55	39.00	40.37	39.00	41.00
1955–56	55.12	53.75	49.50	..
1956–57	49.44	54.19	54.79	..
1957–58	48.00	51.73	50.67	..
1958–59	53.19	54.92	48.25	..
1959–60	48.72	51.98	48.92	..

'ERAGE ANNUAL PRICES OF LINSEED CAKE
(Rs. per maund)

Year	Bombay	Calcutta	Kanpur	Nagpur
1949–50	8.00	9.08	8.78	8.20
1950–51	11.10	13.39	12.52	10.23
1951–52	11.12	13.12	12.12	12.15
1952–53	9.35	10.06	9.44	9.60
1953–54	9.77	10.06	9.31	9.85
1954–55	8.46	..	8.11	..
1955–56	6.94	..	7.56	..
1956–57	9.38	10.42	10.30	..
1957–58	10.33	11.71	10.57	..
1958–59	12.57	14.62	12.06	..
1959–60	13.47	14.42	12.70	..

conform to the specifications of the London Cattle Food Trade Association which require that castor seed and husk content should not exceed 0.005%; oil and protein content should not be less than 39%.

Most of the linseed cake produced by *ghanis* is consumed locally. Oil mills sell their cake to local or distant stockists directly or through commission agents. The quality is judged mainly by the appearance and freshness of cake. Military authorities make purchases on the basis of the following specifications: moisture, $\not>$10; total ash, $\not>$8; ash insol. in hydrochloric acid, $\not>$1.5; crude fibre, $\not>$10; protein, $\not<$28; and fat $\not<$7%. The cake must be free from any harmful constituents or admixture of indigestible fibrous matter, like hair and jute fibre (*Rep. Marketing Linseed*, 1956, 161–68).

Table 20 gives the average annual wholesale prices of linseed cake in some important centres.

LION (Class *Mammalia*, order *Carnivora*, sub-order *Aeluroidea*, family *Felidae*)

D.E.P., VI (4), 49; Pocock, *J. Bombay nat. Hist. Soc.*, 1930–31, **34**, 638; Fn. Br. Ind., Mammalia, I, 1939, 210–22.

SANS.—*Simha, kesari, hari*; HINDI—*Babar-sher, sher, singha*; BENG.—*Singha*; GUJ.—*Untia-bagh*.

KASHMIR—*Such* (male), *siming* (female); KATHIAWAR—*Sawach*.

The lion, as indicated by fossil remains in Europe, must have had its original home in that continent from where it migrated to Africa and South-West Asia and thence to India. At one time, the lion was distributed in northern, eastern and central India, but excessive hunting for sport and for protecting livestock has considerably thinned its population. Lion shooting and poaching have been prohibited and according to 1955 census, about 290 lions are confined to Gir forests in Gujarat. To preserve this rare animal, a lion and two lionesses were introduced into Chakia forest near Varanasi (Uttar Pradesh) in 1957.

The lion differs from other felines in the uniform colouration of the adult; the males are characterized by the presence of a mane on the head, neck and shoulders. The average length of an adult, from the nose to the tip of the tail, is 2.80 m. and the largest specimen on record is 3.228 m. Two main races of lions are distinguishable, viz. the African Lion (*Panthera leo leo* Linn.) and the Asian or the Indian

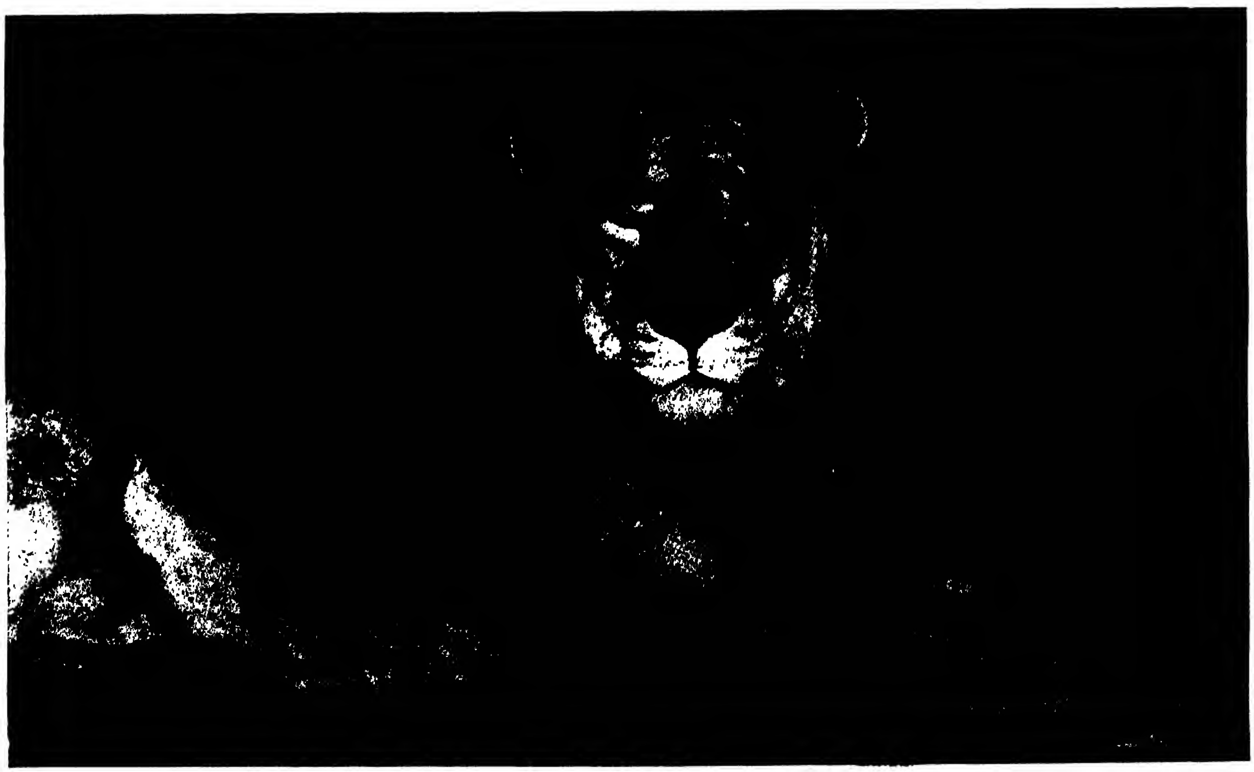


Photo: Maharaja of Baroda

FIG. 48. LION—PANTHERA LEO PERSICA

Lion [*Panthera leo persica* (Meyer)]. The Indian and African lions, though slightly different in appearance, are more or less similar in their habits. The Indian lion is perhaps somewhat stockier and shaggier, with a fuller coat, longer tassel of hair at the end of the tail, a more pronounced tuft of hair on elbow joints and a fuller fringe of hair on the belly ; the mane is comparatively scanty. There are two distinct varieties of Indian lions: the donkey variety which is more vertical-shaped, bigger and fiercer and the waler variety, more horizontal-shaped, smaller and less fierce.

Lions inhabit sandy plains and rocky places with thorny thickets, hunting usually during the night. Except during the breeding season, the lion is quite sociable and roams about in groups. The strength of the lion, for its size, is phenomenal ; it can spring up to the head of the largest of elephants and pull it down to the ground. Though not very swift, it leaps with great violence. The lion does not attack a man unless provoked. Old or maimed animals may become man-eaters and also a menace to livestock. The cattle-lifters make for the nearest village at dusk to prey upon cattle coming home or ambush their grub when the cattle are driven out to pasture before dawn. The lion is noisier than the lioness, particularly during the mating season (Prater, 42 ; Ellerman & Morrison-Scott, 319 ; Encyclopaedia Britannica, XIV, 168–69 : Wynter-Blyth, *J. Bombay nat. Hist. Soc.*, 1948–49, **48,** 493 ; 1955–56, **53,** 527 ; Wynter-Blyth & Dharmakumarsinhji, ibid., 1950–51, **49,** 456 ; Gee, ibid., 1956–57, **54,** 10–12 ; Chaturvedi, *Indian For.*, 1954, **80,** 733).

The life span of a lion is *c.* 30 years : the male is at its prime at the age of 5 years and the lioness is reported to have her first litter when 2½–3 years old, though a lioness only 22 months old is known to have bred. The period of gestation is 116 days and the interval between litters is at least 1½–2 years. In Gir forests many lions mate between October and November and the cubs are born between January and February. Two cubs are usually born in a litter, but sometimes as many as five cubs are born. The lion stays with the family for defence and procurement of food. New born cubs possess a pattern of rosettes like that of a leopard ; later the rosettes coalesce to form looped stripes like those of a tiger and in about six months time, the pattern usually disappears altogether (Sterndale, 76–77 ; Prater, 42 ; Wynter-Blyth, *J. Bombay nat. Hist. Soc.*, 1948–49, **48,** 493).

The lions have been the favourite sport of big game hunters : their heads and skins are valued as trophies ; furs are also esteemed. The fat of the lion has been used in certain parts of India as a cure for rheumatism and paralysis. The body fat (sap. val., 191.5 ; iod. val., 41.0 ; acid val., 16.6 ; unsapon. matter, 2.6%) which is solid at ordinary temperatures has the following fatty acid composition: decanoic, 1.4 ; lauric, 1.1 ; myristic, 4.9 ; palmitic, 28.9 ; stearic, 17.8 ; arachidic, 0.1 ; tetradecenoic, 0.6 ; hexadecenoic, 1.9 ; oleic, 40.3 ; and unsaturated C_{20-22}, 3.0% (Jerdon, 1867, 91 ; Reese, 258 ; Hilditch & Sime, *Biochem. J.*, 1942, **36,** 98).

LIPPIA Linn. (*Verbenaceae*)

A large genus of shrubs or undershrubs, rarely herbs, distributed chiefly in tropical and sub-tropical America ; a few species are found in the tropics of the Old World. Five species occur in India, of which one is ornamental.

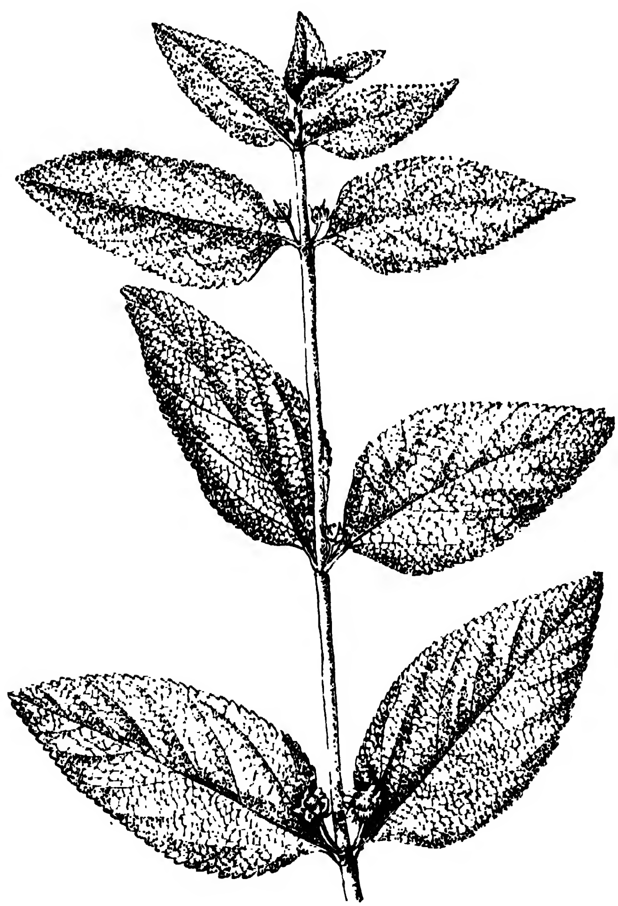


FIG. 49. LIPPIA ALBA—FLOWERING BRANCH

L. alba (Mill.) N.E. Br. syn. *L. geminata* H.B. & K. Fl. Br. Ind., IV, 563.

ORIYA—*Naga-aieri.*

MIKIR—*Lopong-brik*; MUNDARI—*Daru kaini ba*; MADHYA PRADESH—*Basula.*

A strongly aromatic, erect, much-branched shrub, 0.9–2.4 m. high, found in wet situations and muddy river banks from Bihar and Orissa to Assam, Madhya Pradesh, Nilgiris and Anaimalais up to 900 m. Leaves opposite, ovate-oblong or lanceolate, crenulate or crenate; flowers small, purplish or pink, scented, in dense capitate or sub-capitate spikes; fruits globose, dry, splitting into two 1-seeded pyrenes.

The plant is used as a sage in cookery. Leaves are used as vegetable in Khasi hills. They are considered stomachic and nervine in some parts of Brazil and Paraguay. The air-dried leaves from Calcutta yield 0.26% of an olive brown essential oil, with the following characteristics: sp. gr.$^{30°}$, 0.938; $n^{30°}$, 1.4949; $[\alpha]_D$, +1.7°; acid val., 9.40; ester val., 39.6; acet. val., 124.50; insol. in 70–90% alcohol, sol. in chloroform and ether. The constituents of the oil vary with the source of origin: dipentenes, *d*- and *l*-limonene, *l*-piperitone, lippione ($C_{10}H_{14}O_2$, b.p./4 mm., 80–85°), a saturated ketone, *d*-α-pinene, *dl*-dihydrocarvone, citral and camphor have been identified in different samples (Haines, IV, 706; Fl. Assam, III, 461; Uphof, 218; Choudhury & Bose, *Sci. & Cult.*, 1961, **27,** 101; *Chem. Abstr.*, 1955, **49,** 3479; 1957, **51,** 7658).

L. citriodora H.B. & K.—*Aloysia triphylla* (L'Herit.) Britton LEMON VERBENA

Chittenden, III, 1188; Youngken, 705, Fig. 358.

A graceful shrub or small tree, 3–6 m. in height, indigenous to S. America and commonly grown in Indian gardens, especially on hills, where it sometimes attains a considerable size; it can be raised as a pot plant in the plains. Leaves lanceolate, lemon-scented, in whorls of three; flowers small, pale purple, white or lilac, in terminal panicles (Fl. Madras, 1089; Gopalaswamiengar, 291).

L. citriodora is propagated from seeds and cuttings and thrives well on loamy soil mixed with leaf mould. It is the source of the true Oil of Verbena. The plant is naturalized in southern Europe and is cultivated on a small plantation scale in the Grasse region of southern France, Algeria and Tunis (Muenscher & Rice, 79; Guenther, VI, 37; Gopalaswamiengar, 291).

The leaves are used for flavouring beverages, desserts, fruit salads and jellies, for seasoning food and in the preparation of ptisan. They are also used in sachets. A decoction of leaves and flowers is given as febrifuge, sedative and anti-flatulent (Muenscher & Rice, 79–80; Steinmetz, II, 467).

Fresh cuttings of the plant, containing stalks and adhering leaves, yield, on steam-distillation and cohobation, 0.1–0.7% of a greenish yellow essential oil (Oil of Verbena) with an agreeable odour, resembling that of lemon grass oil but more delicate. The characteristics of the oil vary within the following limits: sp. gr.$^{15°}$, 0.890–0.912 (rarely up to 0.920); $[\alpha]_D$, −10° to −18°; $n^{20°}$, 1.482–1.488 (exceptionally 1.4793); sol. in 1–6 vol. of 80% alcohol. The principal constituent of the oil is citral, 26–39%: the oil contains cineole, 4%; terpenes (*l*-limonene and dipentene), 22%; aldehydes and ketones (α- and β-citrals, methyl heptenone, *l*-carvone and traces of furfural), 33%; alcohols (linalool, *d*-α-terpineol, borneol, nerol, nerolidol, geraniol, citronellol and cedrol), 20%; sesquiterpenes (*d*-β-caryophyllene and probably a tricyclic sesquiterpene), 15%; and traces of acetic acid and pyrrole. Concretes and absolutes of verbena have been prepared. True oil of verbena should not be confused with Spanish Verbena Oil, derived from *Thymus hiemalis* Lange or Indian Verbena Oil which is lemongrass oil. True verbena oil is expensive and is produced in small quantities. Most common 'Verbena' oils are skilful blends of citral or fractions of lemongrass oil and natural isolates of other essential oils (Guenther, VI, 37–40; Poucher, I, 416–17; Parry, I, 270; *Chem. Abstr.*, 1934, **28,** 3182).

Verbena oil imparts refreshing tonalities to toilet waters, perfumes and Eau de Cologne; it is used for scenting bath salts. It blends well with various perfumes and may be used for flavouring liqueurs and non-alcoholic beverages. It is an effective insecticide (in 1–2% concentration) against mites and aphids [Guenther, VI, 40; Poucher, I, 417; Betts, *Acta phytother., Amst.*, 1955, **2**(1), 3; Irvine, *Colon. Pl. Anim. Prod.*, 1955, **5,** 34].

L. nodiflora Rich.=*Phyla nodiflora* (Linn.) Greene

D.E.P., V, 78; Fl. Br. Ind., IV, 563; Kirt. & Basu, Pl. 731.

HINDI & BENG.—*Bhui-okra*; MAR.—*Ratoliya*; GUJ.—*Ratveliyo, ratoliya*; TEL.—*Bokenaku, bokkena*; TAM.—*Poduthalai*; KAN.—*Nela-hippali*; MAL.—*Kattu-thippali*; ORIYA—*Bukkan.*

PUNJAB—*Bhuiokra, mokna, bukan.*

A creeping much-branched herb, rooting at the nodes, found in wet places along bunds of irrigation channels, canal edges and river banks almost

throughout India ascending up to 900 m. in the hills. Leaves opposite, small, sub-sessile, cuneate-spathulate or obovate, sharply serrate at the apex ; flowers small, white or pale pink, in axillary heads ; fruits globose-oblong, dry.

The plant is valued for making lawns in Egypt. The leaves are reported to be eaten in Ceylon and an infusion is taken as tea in Philippines. The plant is said to possess cooling, diuretic and febrifuge properties ; it is used in ischury, stoppage of bowels and pain in knee-joints. A paste or poultice prepared from the fresh plant is applied as suppurant (maturant) for boils, swollen cervical glands, erysipelas and chronic indolent ulcers. An alcoholic extract of leaves shows anti-bacterial activity against *Escherichia coli* (Dalziel, 455 ; Macmillan, 302 ; Burkill, II, 1353 ; Kirt. & Basu, III, 1916–17 ; Nadkarni, I, 746 ; George *et al., J. sci. industr. Res.*, 1947, **6B**, 42).

Two glucosidic colouring matters, nodiflorin-A ($C_{28}H_{34}O_{12}$, m.p. 186–87°, yield 0.22%) and nodiflorin-B ($C_{27}H_{34}O_{11}$, m.p. 282° decomp., yield 0.27%), have been isolated from the dried plant ; on hydrolysis, the former yields glucose and nodifloridine-A ($C_{22}H_{24}O_7$, m.p. 128°), and the latter, glucose and nodifloridine-B ($C_{21}H_{24}O_6$, m.p. 168°). Free lactose, maltose, glucose, fructose and xylose have been detected in the aqueous extract of the plant. The plant also contains traces of a non-glucoside bitter substance, an essential oil, resin, and a large amount of potassium nitrate. The diuretic action of the plant is perhaps due to the presence of potassium nitrate (Joshi & Bhakuni, *J. sci. industr. Res.*, 1959, **18B**, 525 ; Chopra *et al., Indian J. med. Res.*, 1945, **33**, 157).

LIQUIDAMBAR Linn. (*Hamamelidaceae*)

D.E.P., V, 78 ; Chittenden, III, 1189.

A small genus of deciduous trees distributed in West and East Asia and North and Central America. All species yield an aromatic balsam, known as Storax or Styrax, used in medicinal preparations and perfumery. The two species of *Liquidambar* from which storax of commerce is derived are *L. orientalis* and *L. styraciflua*, both of which do not occur in India. Storax is imported into India chiefly from France ; small quantities are obtained from U.K. and U. S. A. The quantity imported amounted to 864 cwt. (value, Rs. 67,318) in 1957, 444 cwt. (value, Rs. 65,267) in 1958, 169 cwt. (value, Rs. 41,592) in 1959 and 100 cwt. (value, Rs. 51,356) in 1960–61 (Howes, *Econ. Bot.*, 1950, **4**, 315).

Storax (Sans.—*Silhaka ;* Arab.—*Silaras ;* Pers.—*Meihsila ;* Hindi, Beng., Mar., Guj. & Kan. *Silaras ;* Tel. *Shila-rasam ;* Tam.—*Neri-arishippal ;* Mal.—*Rasamalla*) is not a normal secretion of the tree, but a pathological product obtained as a result of wound stimulation, which induces the cambium to produce new wood with schizo-lysigenous ducts and cavities in which the balsam is secreted. The method of extracting storax differs in the two plants (Hill, 169 ; Youngken, 400).

L. orientalis Mill. (Oriental Sweet Gum), the source of Levant or Asiatic Storax, is a medium sized, much-branched tree, growing to a height of 6–12 m. or more, with truncate, palmately 5-lobed leaves and monoecious, yellow flowers, in globular heads. The plant is a native of Asia Minor ; large forests of the plant are found in the southwestern parts of the country. Its cultivation may be tried in northwest India (Guenther, V, 243 ; Nayar & Chopra, 35).

The collection of storax commences when the tree is 3–4 years old. The bark is bruised or injured by beating and the balsam soon exudes into the inner bark. The outer bark is then peeled and discarded. The inner bark, saturated with balsam, is stripped off and boiled with water which causes the balsam to separate and float to the top whence it is removed. Crude storax thus obtained is poured into barrels, casks or cans for shipment (Guenther, V, 243 ; Hill, 169 ; Finnemore, 351 ; Youngken, 400 ; U.S.D., 1955, 1316).

L. styraciflua Linn. (Sweet Gum, Red Gum), the source of American Storax, is a tall, pyramidal tree, reaching a height of 15–40 m., sometimes even 45 m., found along the Atlantic coast from Connecticut southwards to Central America. The commercial supply of American Storax is now almost exclusively obtained from Honduras where large forests of *L. styraciflua* are found. The storax is not present in all the trees and those containing it, particularly old trees, have to be searched out. The balsam is present as accumulations in small natural pockets beneath the bark ; the pockets are located by collectors as excrescences formed outside the bark and are tapped. The method frequently followed is to make an incision in the excrescence and insert a small gutter ; the viscous exudation flows out slowly into a collecting vessel. It is filled in drums for shipment (Guenther, V, 249–51).

Crude Levant storax is an opaque, greyish to greyish brown, semi-liquid which deposits, on standing, a dark brown oleoresin. Crude American storax is a brownish, viscous or a semi-solid mass which

softens on gentle heating. Indian and British Pharmacopoeias recognize only the Levant storax purified by extraction with alcohol, while U. S. Pharmacopoeia recognizes both Levant and American storax. The purified storax, official under the name Prepared Storax or Styrax Praeparatus, occurs as a yellowish brown, viscous mass, transparent in thin layers and possessing an agreeable balsamic odour and taste. Prepared storax should be completely soluble in 90% alcohol; the material dried over a water bath for 1 hr. should have the following characteristics: total balsamic acids, 30.0%; acid val., 55–90; ester val., 100–133; sap. val., 170–200; and loss on drying in a thin layer, 5.0%. Commercial samples are often adulterated with turpentine, rosin, castor or olive oils, labdanum and other resins (Guenther, V, 243–54; B.P., 1958, 623–24; U.S.P., 1955, 674; I.P., 590; Fuller, 714).

Purified storax is composed principally of an alcoholic resin, named storesin (33–50%) occurring free and as cinnamic ester; it contains also free cinnamic acid (5–15%), cinnamyl cinnamate or styracine (5–10%), phenylpropyl cinnamate (c. 10%), and small amounts of ethyl cinnamate, benzyl cinnamate, styrene (phenylethylene), a pleasant smelling liquid probably styrocamphene, and traces of vanillin. Steam-distillation of storax yields a pale yellow to dark brown volatile oil, Oil of Storax, with a pleasant but peculiar odour. The commercial oil is distilled exclusively from American storax (yield, 15–20%); the yield from Levant storax is poor (0.5–1.0%). The yield of oil and its composition depend upon the method and duration of distillation. Besides styrene and cinnamates, the oil contains free phenylpropyl and cinnamyl alcohols and cinnamic acid (Merck Index, 905–06; Guenther, V, 246–49, 253–54).

Storax is used for scenting soaps and cosmetics, as a fixative for heavy perfumes, in the preparation of adhesives, lacquers and incense and as an ingredient of many pharmaceutical preparations; it is used also for flavouring tobacco. Oil of storax is an ingredient of several perfume compounds, particularly those of oriental character. The residual bark (from *L. orientalis*) left after the extraction of balsam is used for fumigation [Hill, 169; Krishna & Badhwar, *J. sci. industr. Res.*, 1949, **8**(11), suppl., 192; Guenther, V, 254].

Storax resembles balsams of Peru and Tolu (from *Myroxylon* spp.) in its action and is used as a stimulating expectorant and antiseptic, and in ointments for scabies and other parasitic skin diseases. It is at present seldom used in medicine except as an ingredient of Tinctura Benzoini Composita. A syrup prepared from the bark of *L. styraciflua* is used in dysentery and diarrhoea (Martindale, I, 278; U.S.D., 1955, 1317; I.P., 590).

L. formosana Hance (Fragrant Maple) is a handsome tree, growing to a height of 25–30 m., with 3-rarely 5-lobed leaves, indigenous to south and central China. It has been introduced into India and is reported to be grown in Lalbagh gardens, Bangalore (Chittenden, III, 1189; Krumbiegel, 35).

The tree yields a balsam, known as Chinese Storax, similar to Levant storax. It contains cinnamic acid (16%), cinnamyl alcohol, borneol, a resin alcohol (probably storesin), and volatile constituents (1.8–8%). The leaves on steam-distillation yield 0.05% of a volatile oil consisting principally of terpenes (88%), *l*-α-pinene, camphene and β-pinene predominating (Krishna & Badhwar, loc. cit.; Fuller, 713; Wehmer, I, 432; *Chem. Abstr.*, 1934, **28**, 3524).

The wood of *L. formosana* (cellulose, 50.3; lignin, 30.6; and pentosan, 19.2%) has been tried as a source of paper pulp in Formosa. It is used for tea chests in China. In Kwantung, leaves are used as food for silkworm (*Chem. Abstr.*, 1940, **34**, 5656; Krumbiegel, 35; Chittenden, III, 1189; Uphof, 218).

Liquorice — *see* **Glycyrrhiza**

Liquorice, Indian — *see* **Abrus**

LIRIODENDRON Linn. (*Magnoliaceae*)

Bailey, 1947, II, 1890, Pl. LXVI.

A small genus of trees native of North America and China. *L. tulipifera* (Tulip Tree), a native of eastern North America, has been introduced into some hill stations in India.

L. tulipifera Linn. is a tall deciduous tree with pyramidal habit, at times attaining a height up to 75 m. (bole, 30 m.) and diam. 4.2 m.; usually, it is much smaller. Bark thin and scaly in young trees, becoming thick and furrowed with age; leaves simple, trilobed, 7.0–15.0 cm. long and nearly as broad, with truncate apex and roundish base; flowers tulip-shaped, greenish yellow, orange within, fragrant; fruit brown, cone-like.

The tulip tree is grown in gardens for its handsome foliage and large flowers. It is well adapted for planting as shade tree in parks and avenues and in hedges. It thrives in well-drained sunny situations and may be propagated by transplanting seedlings or by layering. A number of horticultural varieties are known to exist (Osborn, 403).

L. tulipifera is a valuable forest tree in U.S.A. and the source of YELLOW POPLAR, WHITE WOOD or CANARY WOOD of commerce. The timber is yellowish brown in colour, lustrous, soft, light (wt., 25–30 lb./cu.ft.) with fine straight grain. It is stiff and durable, though not very strong, and is easy to season and work. It is used for mill work, furniture, carving, musical instruments, boats, light constructions and veneers. The wood has been tried as a raw material for paper pulp; it contains: total cellulose, 35.6; and α-cellulose, 28.55%. The pulp obtained by kraft process is comparable to commercial pulps in strength but is somewhat difficult to bleach (Howard, 643–44; Record & Hess, 345; Hill, 104; Titmuss, 142; Chen & Cameron, *Industr. Engng Chem.*, 1942, **34,** 224; *Chem. Abstr.*, 1955, **49,** 9274).

The bark of the root, trunk and branches is a bitter aromatic, antipyretic and diaphoretic. It has been used in rheumatism, dyspepsia and as anti-malarial. The root bark contains an alkaloid (tuli-piferin), traces of a glycoside, essential oil, yellow colouring matter and tannin. A lignan diglucoside, liriodendrin ($C_{34}H_{46}O_{18}$, m.p. 269–70°) has been isolated from the inner bark (Hocking, 128; Tchon, 74; Dickey, *J. org. Chem.*, 1958, **23,** 179; U.S.D., 1947, 1507; Wehmer, I, 336).

The leaves are reported to be eaten by cattle; they contain hydrocyanic acid, but only in traces. The flowers secrete an abundance of nectar; the nectar available to bees from a single tree is reported to be sufficient for 2.16 lb. of honey, reddish amber in colour and of good flavour (*Jt Publ. imp. agric. Bur.*, No. 10, 1947, 163; *Chem. Abstr.*, 1939, **33,** 2181; Marvin, *J. econ. Ent.*, 1933, **26,** 170).

LITCHI Sonn. (*Sapindaceae*)

A genus of trees comprising two species, *L. philippinensis* Radlk. found wild in the Philippines and *L. chinensis* indigenous to southern China and cultivated widely for its edible fruits.

L. chinensis (Gaertn.) Sonn. syn. *Nephelium litchi* Cambess. LITCHI, LYCHEE

D.E.P., V, 346; C.P., 793; Fl. Br. Ind., I, 687; Ochse *et al.*, I, 726.

HINDI & BENG.—*Lichi.*

An evergreen tree, 10–12 m. high, with broad round-topped crown of glossy green foliage: leaves pinnate with 2–9 leaflets; flowers polygamous, small, greenish white or yellowish, in terminal panicles; fruit globose or oblong to ovate, 2.5 cm. or more in diam. with a dark or light red or yellow rind, faintly or sharply tubercled and brittle; aril fleshy-white, translucent, juicy, covering fully a large, dark brown, elliptic seed.

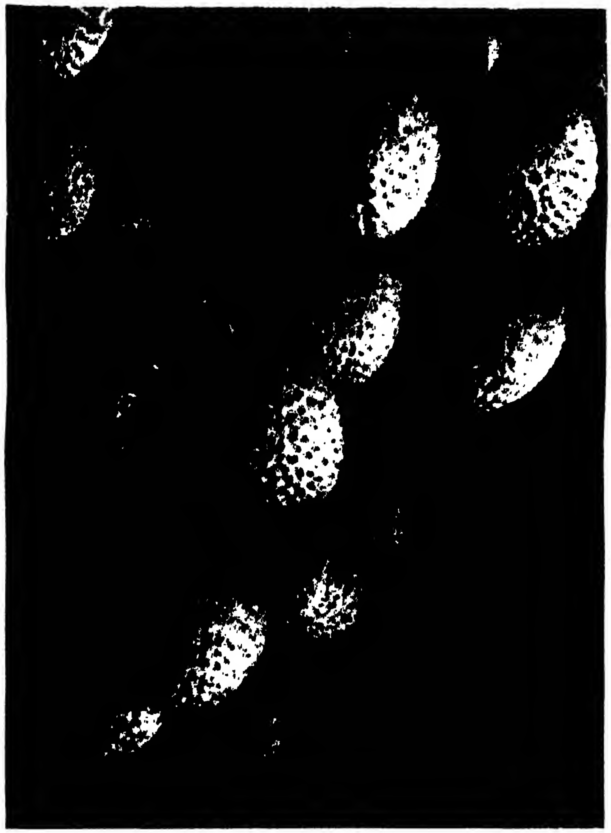


FIG. 50. LITCHI CHINENSIS—FRUITING BRANCH

Litchi is reported to have been introduced into India from China towards the end of the eighteenth century. It is now cultivated in a number of countries, outside China, including India, Burma, Indo-China, Thailand, S. Japan, Formosa, Australia, New Zealand, Hawaii, U.S.A., Brazil, West Indies and South Africa; India and South Africa are the largest producers outside China (Popenoe, 315; Hayes, 277; Marloth, *Fmg in S. Afr.*, 1947, **22,** 823, 863; Singh & Singh, 2).

The total area under litchi in India is estimated at 23,950 acres, of which 23,600 acres are in N. Bihar, mostly in Muzaffarpur and Darbhanga districts. The rest of the area under litchi lies in the sub-montane districts of Saharanpur, Dehra Dun and Muzaffarnagar in Uttar Pradesh; it has been successfully cultivated also in Gorakhpur, Deoria, Gonda, Basti, Faizabad, Rampur, Bareilly, Bahraich, Kheri and

Pilibhit districts. Litchi is cultivated to a small extent near Hooghly in West Bengal and near Pathankot in Punjab. Though favourable conditions for its culture exist in many parts of S. India, it is almost unknown there; a few plants are found in Kallar and Burliar Fruit Research Stations (Nilgiris) and in the vicinity of Bangalore. Recent studies have indicated the possibility for growing litchi in Araku valley (Visakhapatnam dist., Andhra Pradesh) with protection against hot winds in summer (Singh & Singh, 2–3; Hayes, 277; Naik, 405; Somayajulu, *Andhra agric. J.*, 1955, **2**, 314; 1957, **4**, 88).

The cultivated types of litchi are numerous and form a complex evidently derived from more than one wild progenitor. They are so intermingled, that it is not possible to locate their geographical distribution. As many as 74 types are reported to be under cultivation in China, of which 15 are considered important. The better types have larger fruits with small, frequently abortive seeds and bear heavily. In India, considerable confusion exists regarding the classification and nomenclature of types cultivated in Bihar and U.P. In Bihar, out of 33 selected types falling under 15 categories ten have been recommended for large scale cultivation, viz. *Purbi, Kasba, Bedana, Early Bedana, Late Bedana, Bedana Dehra Dun, Desi, China, Rose* and *Dehra Rose*. Similarly, twelve types from among those grown in Saharanpur and Dehra Dun in U.P. have been described and five have been recommended for cultivation, viz. *Late Seedless, Early Large Red, Kalkattia, Rose-Scented* and *Gulabi*; of these *Late Seedless* and *Kalkattia* are comparatively more resistant to hot winds (*loo*) than others. In Punjab, some fine orchards have been established in Panjore (Ambala dist.) and near Pathankot and the types commonly grown are *Panjore Common, Rose-Scented, Bhadwari, Seedless No. 1 & 2, Dehra Dun* and *Kalkattia*. *Panjore Common* is a heavy bearer and is recommended for commercial cultivation (*Hort. Abstr.*, 1955, **25**, 140; Ochse *et al.*, I, 728; Singh & Singh, 27, 71; Vyas, *Bull. Dep. Agric., U.P.*, No. 12, 1943; Singh & Sarin, *Indian J. Hort.*, 1957, **14**, 103).

Climate & Soil—Litchi is rather exacting in its requirements of soil and climate; for successful culture the following requirements are considered essential: (*i*) humid atmosphere, (*ii*) freedom from injurious frosts, (*iii*) abundance of soil moisture, and (*iv*) deep loamy soil; it does not fruit well in tropical regions, except at elevations high enough to be cold. The limiting factor for its extensive cultivation in the large tracts of Uttar Pradesh, which are otherwise well suited, is the prevalence of hot dry wind (*loo*) during May–June, which causes the skin of the ripening fruit to split and renders it unmarketable. A moderately heavy rainfall (*c.* 60 in./year) and high humidity (69–84%), as obtaining in southern China, are ideal for litchi culture, but these are not essential if the orchard is irrigated as in parts of Bihar and U.P. (Popenoe, 317, 319; Chandler, 324; Hayes, 278–79; Singh & Singh, 14–17).

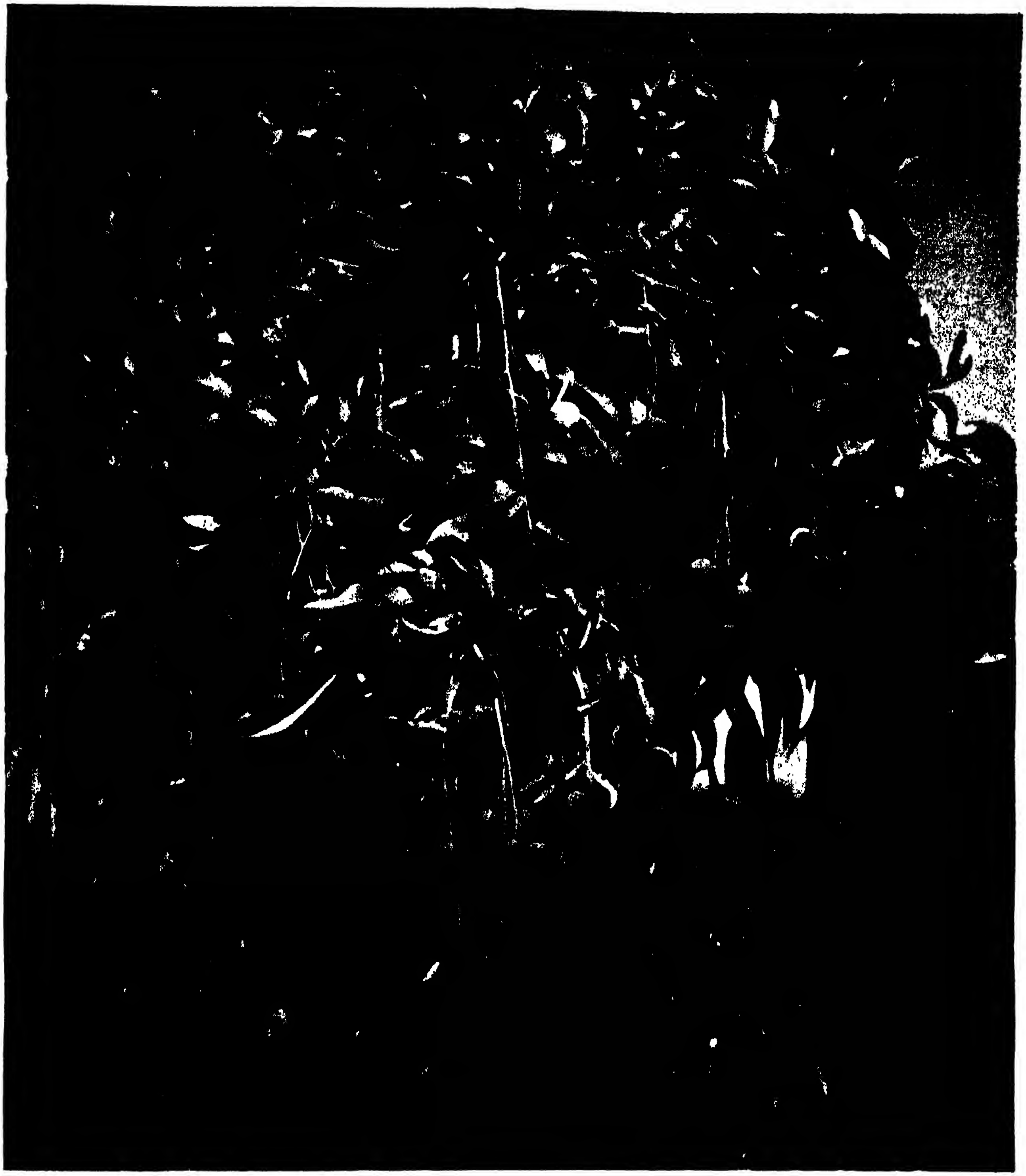
The litchi is said to succeed best when planted in deep rich soil near banks of irrigating canals. It does well on sandy loam, but a considerable proportion of clay is an advantage. The soils of litchi growing areas in Bihar and U.P. are rich in lime, but its growth is satisfactory on many types of soils, provided they are deep and well-drained. In South Africa, the tree grows vigorously on acidic soil and under such conditions, a beneficial fungus is found in mycorrhizal association with roots (Singh & Singh, 17; Hayes, 279; Vyas, loc. cit.; Marloth, loc. cit.).

Propagation & Culture Litchi is usually propagated vegetatively. It can also be grown from seedlings, but trees so raised are variable in fruit quality and take long to come to bearing. Most cultivated types do not produce an abundance of seeds; further, seeds lose their viability rapidly if allowed to dry after separation from the fruit. Propagation by seed is recommended only for raising rootstocks for grafting purposes.

Among the vegetative methods of propagation, air layering or gootee or some modification thereof is the practice in India. The best time for layering is June and layers are ready for transplantation in the nursery during the monsoon; nursery plants are ready for planting in the orchard during the following monsoon. Propagation by cuttings, inarching and grafting is possible, but is not commonly employed (Singh & Singh, 11–14; Naik, 405; Hayes, 279–80; Vyas, loc. cit.).

Layers are planted in pits 3 ft.×3 ft.×3 ft., dug 30 ft. apart, and filled with a mixture of well rotten farmyard manure, leaf mold and silt. Young plants are sensitive to frost and are protected during winter by thatch (Vyas, loc. cit.; Singh & Singh, 17–18).

In Bihar, where the soil is naturally fertile, no manure or irrigation is given. Irrigation is necessary from January till the break of the monsoon in the dry areas of U.P. A mixture of leaf mold or farmyard manure fortified with castor or neem cake, bonemeal and wood ash is applied in December when new



Indian Coun. Agric. Res., New Delhi

LITCHI CHINENSIS — FRUITING BRANCHES

shoots are about to appear; fish or fish meal (6–8 lb./tree) may also be applied. Mulching of fallen leaves or other organic matter in beds or basins round plants is recommended. A dressing of potash, phosphate and calcium, in quantities appropriate to the age of the tree, is beneficial. Pruning is practised to some extent in China and Burma, particularly when crowding occurs. Pruning is said to improve yield and quality of fruits in old trees [Singh & Singh, 18–20; Vyas, loc. cit.; Hayes, 281; Popenoe, 319–20; Singh, *Indian J. Hort.*, 1952, **9**(4), 53: Katyal & Chadha. *Fertiliser News*, 1961, **6**(4), 9].

Diseases & Pests—Hardly any serious disease has been reported on litchi. A leaf spot, caused by *Pestalotia pauciseta* Sacc., affects the leaves; the spots which are of brownish colour are particularly conspicuous on the lower surface of the leaf. The incidence of the disease is high in December. Spraying with lime-sulphur is effective in controlling the severity of the disease [Tandon *et al.*, *Proc. nat. Acad. Sci. India*, 1952, **22B**(1–5), 21].

A number of insect pests are recorded on litchi; the most severe among them in India is litchi mite (*Eriophyes* sp.) causing leaf curl. Young leaves are more commonly attacked than old ones. Removal and burning of infected leaves and branches is recommended as a control measure. Painting the stem with coal tar or banding with cloth soaked in crude oil emulsion prevents mites from climbing up the stem. Spraying with crude oil emulsion, or kerosene and flowers of sulphur, or soft soap and flowers of sulphur, or 0.5% D.D.T. is effective in controlling the pest. A bark-eating caterpillar (*Indarbela tetraonis*) bores into the bark and underlying tissues of older trees; it is checked by plugging holes with carbon disulphide, petroleum or formalin and plastering with mud during October–November [Singh & Singh, 23–25; Hayes, 282; Roy & De, *Indian J. Hort.*, 1950, **7**(1), 16].

Bats and birds cause much damage particularly at the time of fruit ripening. They may be kept away by netting the trees (Vyas, loc. cit.: Singh & Singh, 26).

Fruiting & Harvesting—Layered trees come into bearing in 3–6 years of planting: seedling trees take 8–12 years. The tree bears staminate, hermaphrodite and pseudo-hermaphrodite flowers. Flowering starts a few weeks after the cold weather. Spraying in early autumn with sodium naphthalene acetate increases spring flowering. In regions in which the spell of cold weather is brief, flowering takes place intermittently and in flushes. Whole branches of the tree or the entire tree may bear only hermaphrodite flowers for a short period during which no pollen is shed, though pistils are functional; this affects the setting of the crop. The failure of some litchi trees in the plains of S. India is attributed, among other causes, to low percentage of flowers with normal pistils. In most parts of N. India, trees come to flower in February; in Bangalore, the trees blossom twice a year; in Kallar and Burliar, blossoms appear usually in December. Pollination is necessary to stimulate fruit development and seedless fruits, in which seeds are shrivelled, result from non-fertilization due to self- or cross-sterility [Khan, *Agric. J. India*, 1929, **24**, 183; Chandler, 321–22; Shigeura. *Rep. agric. Exp. Sta. Univ. Hawaii*, 1946–48, 138; Nakata, *Bot. Gaz.*, 1955–56, **117**(1), 126; Singh & Singh, 6–8; Naik, 406; Hayes, 283].

Fruits are harvested from the middle of May to the end of June or July in most areas of N. India. Fruits are picked from April to May in Nilgiris. The maturity of fruit is indicated by colour, flatness of tubercles and brittleness of epicarp. Harvesting is usually done by breaking off long bits (*c.* 1 ft.) of the stem with bunches of fruits, as this serves the dual purpose of pruning the tree and delaying the wilting of fruit. For the local market, fruits are allowed to remain on the tree until fully ripe; for distant places, fruits are picked when they are just beginning to turn red. The yield increases gradually from year to year until the trees reach their prime (*c.* 20 years); trees remain in profitable bearing for more than a century. A five year old tree may give *c.* 500 fruits, while a tree at its prime may give 4,000–5,000 fruits (160 to 330 lb.) per annum. Individual trees are reported to have given as many as 15,000 fruits (1,000 lb.), while in China yield as high as 1,500 lb. per tree has been reported (Singh & Singh, 20; Hayes, 283; Naik, 406; Vyas, loc. cit.).

Storage—Litchi fruits are usually consumed fresh. They remain in fit condition for 3–5 days, after which they get discoloured and spoiled; they may be kept for a slightly longer period, if pre-treated with 0.5% copper sulphate solution and stored in perforated polythene bags. Fruits may be dried by exposure to sun and air for about 2 weeks, when they lose *c.* ⅔ of their weight; they may be dried in forced draft tunnel dehydrators and packed in vacuum sealed cans. Dried fruits have brown and brittle skin and dark brown shrunken aril; the flavour of dried aril is distinct from that of fresh aril but still pleasant.

Dried fruits, Litchi Nuts as they are called, are produced in China and exported to Europe and America for use in Chinese restaurants [Hayes, 284; Singh & Singh, 21; Singh, *Indian J. Hort.*, 1957, **14,** 205; Pal, *Indian Fmg. N.S.*, 1951–52, **1**(3), 13; *Bull. cent. Fd technol. Res. Inst., Mysore*, 1955–56, **5,** 145].

Under optimum conditions of cold storage (32–35° F. and 85–90% humidity) litchi can be preserved for about 10 weeks; the period can be slightly prolonged by wrapping the fruits in polythene bags. The fruits lose their attractive colour but they taste somewhat sweeter than fresh fruits. When packed along with moss or leaf in polythene bags and stored at 45°F., ripe fruits retain their fresh colour and appearance for about 2 weeks; semi-ripe fruits can be kept well for a year or more under cold storage (*Bull. cent. Fd technol. Res. Inst., Mysore*, 1954–55, **4,** 215; Verma & Roy, *Proc. Bihar Acad. agric. Sci.*, 1953–54, **2** & **3,** 128; *Biol. Abstr.*, 1956, **30,** 4194–95, 4205; Mukerjee, *Sci. & Cult.*, 1955–56, **21,** 603; 1957–58, **23,** 101; Chandler, 323).

Litchi arils can be preserved by canning with syrup. Among the types tested, *Purbi* appears to be the best for canning purposes. Addition of 4% tartaric acid solution to the syrup checks browning. Canning is done in parts of U.P. and Bihar [Porterfield, *Econ. Bot.*, 1951, **5,** 30; Miller *et al.*, 92, 178; Singh & Singh, 21–22; Verma & Ahmad, *Indian Fd Packer*, 1957, **11**(2), 7].

Marketing The grower usually sells the produce, far in advance, to a middle man or contractor who purchases the entire crop. Fruits intended for despatch to distant markets (requiring 3–4 days for transport) are picked when yellow with slight reddish tinge and packed along with leaves or moss in small bamboo baskets (10 in. deep) or wooden boxes (1½ ft. × 1 ft. × 1½ ft.). In China, a solution of common salt is sprinkled over fruits to prevent rapid spoilage (Vyas, loc. cit.; Verma & Roy, loc. cit.; Singh & ...1, 21–22).

Utilization—The litchi fruit (wt., 8.8–22.2 g.) consists of peel (8–15%), aril (70–86%) and seed (4–18%). The aril, which can be readily separated from seed, is soft and juicy with a delicious flavour and is generally eaten fresh. It yields 38.7–58.7% of juice (density, 16.0–18.6° Bé) containing: total sugars (as invert sugar), 12.1–14.8; reducing sugar, 9.0–13.7; non-reducing sugar, 1.0–3.4; acidity (as citric acid), 0.22–0.36%; and ascorbic acid, 34.5–45.4 mg./100 g. Analysis of fresh arils gave the following values: moisture, 84.5; protein, 1.0; fat (ether extr.), 0.3; carbohydrates, 13.6; fibre, 0.4; and mineral matter, 0.5%: calcium, 10 mg.; phosphorus, 30 mg.; iron, 0.4 mg.; thiamine, 28 μg.; nicotinic acid, 0.4 mg.; riboflavin, 61 μg.; and ascorbic acid, 24 mg./100 g.; carotene, nil (Belavady & Balasubramanian, *Indian J. agric. Sci.*, 1959, **29,** 151).

The fruit shell is reddish brown in colour and contains cyanidin diglycoside and a yellow anthoxanthin. The bark of the tree contains tannin (Singh *et al.*, *Indian For.*, 1958, **84,** 571; Sharma & Seshadri, *J. sci. industr. Res.*, 1955, **14B,** 211).

Litchi seeds are used in Indo-China for intestinal troubles; in Malaya, they are used as anodyne and prescribed in neuralgic disorders and orchitis (Kirt. & Basu, I, 637).

LITHIUM MINERALS

Lithium (at. wt., 6.94; at. no., 3; $d^{20°}$, 0.534; m.p., 186°) is a metallic element belonging to the alkali group of metals. Though more widely distributed in the earth's crust (c. 0.004%) than lead or tin, deposits of lithium minerals in commercially exploitable concentrations are limited. Lithium is found in traces in mineral waters and in plants and animal organisms.

The common lithium minerals are: *amblygonite, lepidolite, lithiophilite, petalite, spodumene* and *zinnwaldite*. The lithia (Li_2O) content of the minerals varies from 2 to 10%. They are usually found as constituents of 'complex type' of granite pegmatite.

Amblygonite [Li Al. PO_4 (F, OH); Li_2O, 8–10%; sp. gr., 3.1; H., 6] is a fluo-phosphate of lithium and aluminium with hydroxyl replacing part of the fluorine. The mineral is usually massive, cleavable and white. It resembles white felspar but is heavier. Transparent varieties are also known.

Lepidolite [chiefly $KLiAl_2Si_3O_{10}$ $(OH, F)_2$; Li_2O, 3–5%; sp. gr., 2.8–3.0; H., 2.5–4.0] commonly known as lithium mica, is a silicate of aluminium, potassium and lithium, with variable amounts of hydroxyl and fluorine. It occurs in compact aggregates of small scales and is characterized by a lilac, purple or rose-red colour. Cookeite is a secondary pink or white hydrous lithia mica, sometimes found in association with red or green tourmaline, lepidolite and spodumene. It exfoliates when heated.

Lithiophilite [Li (Mn, Fe) PO_4; sp. gr., 3.48; H., 4.5–5.0] is a lithium manganese phosphate, usually containing iron as a partial replacement of manganese. The mineral in which the manganese is wholly replaced by iron is termed as Triphylite (Li_2O, FeO.

P_2O_5). Lithiophilite is salmon-pink or clove-brown in colour.

Petalite ($Li_2O.\ Al_2O_3.\ 8\ SiO_2$; Li_2O, 2–4% ; sp. gr., 2.39–2.46 ; H., 6.0–6.5) is a lithium aluminium silicate, found in association with lead minerals. It is usually massive, cleavable, and white or greyish in colour.

Spodumene ($Li_2O.\ Al_2O_3.\ 4\ SiO_2$: Li_2O, 8.4% ; Li, 3.73% ; sp. gr., 3.15–3.20 ; H., 6.5–7.0) is lithium aluminium silicate occurring as distinct prismatic crystals, often of large size, with square or rounded cross-section ; it is also found as massive ore with broad cleavage surface. The mineral is usually dull greyish white. The transparent emerald-green (Hiddenite) and purple (Kunzite) varieties are used as gemstones.

Zinnwaldite (lithium-iron mica) [$K(Li, Fe, Al)(AlSi_3)O_{10}(OH, F)_2$; Li_2O, 2–3%] has the composition of biotite mica, but contains lithium in addition. It is one of the rare micas and usually occurs in small crystals or flakes. It is pale yellow, brown, grey or violet in colour.

DISTRIBUTION

Bihar—Lepidolite is found as an accessory mineral in some of the pegmatites and granite veins of the Bihar mica field. In Hazaribagh dist., it occurs in considerable quantity in a granite dyke, south-west of Pihra (24°38′:85°48′30″). The dyke is composed of white felspar, quartz and irregular masses of scaly aggregates of lepidolite (violet red to greyish violet in colour) in which small grains and crystals of cassiterite are disseminated. An analysis of the violet red variety of lepidolite showed the mineral to contain 3.71% lithia. Lepidolite has been located in another dyke south-east of Pihra and also north of Bhuladi (24°41′:85°47′). About a mile south of Manimundar (24°37′:85°49′) blocks of lepidolite are found strewn on the sides of the hill. In Monghyr dist., lepidolite occurs in pegmatites near Bijaiya and Asarhua [Mallet, *Rec. geol. Surv. India*, 1874, **7**(1), 43 ; *Indian Miner.*, 1958, **12**, 174].

Kashmir—In Padar dist., transparent crystalline blocks of lilac-coloured amblygonite is sometimes found in a valley north of the sapphire mines of Soomjam (33°27′:76°23′). The mineral occurs in granite and is associated with green lithia-tourmaline and cookeite [La Touche, *Rec. geol. Surv. India*, 1890, **23**(2), 65 ; Mallet, ibid., 1905, **32**(3), 228].

Madhya Pradesh—In Bastar dist., two deposits of lepidolite-bearing pegmatite have been located, near Mundval (18°39′:81°56′). The mineral occurs in fine-grained masses and analyses to 3.34% lithia and 4.88% fluorine. Of the two deposits, one occurs about 360 m. south of Mundval and extends east-west for about 270 m. ; it outcrops again along the same strike c. 360 m. further west. The other deposit is found in a hill 550 m. south-west of the locality. Several hundred tons of lepidolite are reported to be available in the region [Crookshank, *Rec. geol. Surv. India*, 1935, **69**(1), 38 ; 1936, **71**(1), 45 ; Krishnan, ibid., 1939, **74**(3), 421].

Mysore—Spodumene is found in some of the pegmatites at lower levels of Ooregaum mine, Kolar Gold Field. The mineral (Li_2O, 5.80%), which is green in colour, is associated with small quantities of lithia mica and lithiophilite, and some of it has altered into greenish and pinkish muscovite-like material (Rao & Rao, *Rec. Mysore geol. Dep.*, 1938, **37**, 38).

Rajasthan—In the south-west part of the former Jodhpur state, lepidolite occurs as an accessory mineral in some granite porphyries associated with the Jalor granite [Ghosh, *Rec. geol. Surv. India*, 1933, **67**(1), 60].

BENEFICIATION

The three important lithium-bearing minerals, namely, amblygonite, lepidolite and spodumene occur in pegmatites in lumps or masses, commonly in association with felspar and quartz. They are, therefore, to be first hand-picked and sorted. Amblygonite and spodumene, if closely associated with pegmatite, are crushed and subjected to gravity concentration. A simple method of concentrating spodumene consists in calcining the ore, preferably in shaft kilns, at 1070°–1080°, when it is transformed from the original α-form into a soft pulverulent β-form. The calcined product is then selectively ground in a pebble mill (wooden blocks may also be used in place of pebbles) and recovered by screening, or air flotation.

The average specific gravity of lepidolite is 2.85, not much higher than that of the usual gangue minerals ; and ordinary gravity methods are not satisfactory for concentrating this mineral. It is necessary, therefore, to resort to air flotation or other suitable method after preliminary hand-sorting and crushing.

EXTRACTION OF LITHIUM

The method employed for the extraction of lithium from lepidolite consists in heating the finely ground ore with an excess of potassium sulphate when lithium sulphate is formed. The material is

extracted with water and the extract treated with caustic potash to precipitate iron and manganese as hydroxide. Lithium is separated from the solution as lithium carbonate by treatment with sodium carbonate (Laidler, 4).

For recovering lithium from spodumene, the ore is roasted to *c.* 1100° to convert α-spodumene to the pulverizable β-variety. The material is then treated with sulphuric acid under critical conditions of time and temperature to bring about substitution of lithium by hydrogen in the mineral. The lithium sulphate thus formed is leached out from the residue, and lithium recovered from the leachate as carbonate.

Lithium metal is commercially produced by the electrolysis of fused chloride. A fused mixture containing 52% lithium chloride (*c.* 95% purity) and 48% potassium chloride is used for electrolysis; lithium bromide is sometimes added. Graphite or carbon is used as anode and cast steel as cathode. Lithium metal of 99.5% purity is obtained by using a bath composition with low melting point to avoid metal fog; contact with nitrogen and water is prevented and the bath is kept free of iron oxide, silica, sulphates, barium, calcium and sodium (Kirk & Othmer, I, 432; *Indian Miner.*, 1958, **12,** 64; Laidler, 16).

Lithium is a silvery white metal and the lightest of elements which are solid at ordinary temperature. It tarnishes in moist air. It is harder than other alkali metals, but softer than lead. It decomposes water at ordinary temperature, liberating hydrogen and forming lithium hydroxide. It burns in air or oxygen to give lithium oxide and forms lithium nitride when heated in nitrogen. Lithium has two isotopes, 6 and 7.

USES

Some of the lithium minerals find direct use in industry. Lepidolite is used in the glass industry as a fluxing agent on account of its high content of potash and fluorine, in addition to lithia. It is a good opacifier and is used in the manufacture of opal, and white opaque and heat-resisting glasses. Spodumene in the β-form is used in the production of whiteware ceramics.

Lithium salts are employed in the glass and ceramic industry for the production of certain types of glasses, glazes and enamels. Lithium carbonate enhances the gloss of glazes used for table and sanitary ware; it is used also for increasing the strength and resistance to weathering of glazes used for electrical porcelain. Lithium fluoride is used for similar purposes. Lithium fluoride and fluophosphate are used in the production of enamels. Lithium chloride and bromide are extremely hygroscopic and find application in air-conditioning. Lithium chloride is used in welding fluxes, especially for aluminium. Lithium hydroxide is used in the manufacture of lithium stearate used in special purpose lubricating greases. It is also used for absorbing carbon dioxide in confined working spaces, e.g. submarines. Lithium salts are used in fireworks to produce red colour. Lithium nitrate and perchlorate contain *c.* 70% and 60% of oxygen and may be used as oxygen donors in some missile fuels. During World War II, lithium hydride was used as a source of hydrogen for balloons employed for sea and air rescue operations.

Both lithium carbonate and chloride have fungicidal properties and are sometimes added to citrate beverages. Lithia water, containing soluble citrate or carbonate, is sometimes used for assisting in the elimination of uric acid in the treatment of gout and rheumatoid affections. In large or concentrated doses, lithium salts cause unpleasant symptoms and thus should be taken in high dilution.

Lithium is used as a degasifier and refining agent for copper, nickel and other metals. It is added to aluminium, magnesium, lead and zinc as an alloying agent to improve their hardness, toughness and tensile strength.

There has been no production of lithium minerals in India. The requirements of Indian industries are met by imports. The more important producers of lithium minerals are U.S.A., South-West Africa and Argentina.

LITHOCARPUS Blume (*Fagaceae*)

A genus of evergreen trees, sometimes shrubs, distributed chiefly in South-East Asia, China and Japan; one species occurs in western North America. This genus was previously considered a synonym of *Quercus* Linn.; a few species were dealt with under *Pasania* Oerst. by some authors. About twelve species are found in India.

L. fenestratus (Roxb.) Rehd. syn. *Quercus fenestrata* Roxb.

D.E.P., VI (1), 380; Fl. Br. Ind., V, 608.

BENG.—*Kala chakma.*

NEPAL—*Arkaula*; LEPCHA—*Kashiendung*; ASSAM & MANIPUR—*Kuhi, ka-diengjing.*

A tree, 9–12 m. in height and 0.9–1.2 m. in girth,

with a bole 4.5–6.0 m. long, found in eastern Himalayas, Assam and Manipur up to an altitude of 2,400 m. Bark greyish brown, fissured, exfoliating in irregular scales; leaves elliptic-oblong to lanceolate, very variable; flowers in tomentose panicles or fascicles, monoecious; fruit (acorn) a globose nut, almost enclosed by the cupule.

L. fenestratus is regarded as a suitable fuel and timber tree for cultivation in tea estates in Darjeeling. Sapwood pale; heartwood red, hard and heavy (wt., 56 lb./cu.ft.); it is used for building purposes and agricultural implements in Khasi hills (Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 147; Fl. Assam, IV, 317; Gamble, 680).

The bark and acorns are reported to be used for dyeing in Manipur. The bark contains 10–16% tannin and can be employed as a tanstuff: it gives a leather of light colour (Badhwar *et al.*, *Indian For. Leafl.*, No. 72, 1949, 15).

L. pachyphyllus (Kurz) Rehd. syn. *Quercus pachyphylla* Kurz

D.E.P., VI(1), 385; Fl. Br. Ind., V, 608; Kirt. & Basu, Pl. 913.

NEPAL *Sungure katus*; LEPCHA *Srikung*.

A tall tree, 24 36 m. in height and 3.6–4.5 m. in girth with a bole 9–12 m. long, found in eastern Himalayas and hills of Assam: a variety, var. *fruticosa*, met with in Manipur at altitudes of 1,500–3,000 m., is only a shrub or a small tree. Bark grey brown, rough; leaves elliptic to oblong-lanceolate; flowers in spikes, monoecious; nut (acorn) depressed-globose, almost entirely enclosed in cupules which are confluent, forming irregular masses.

Natural reproduction of *L. pachyphyllus* is rather poor; a large percentage of acorns are infertile and subject to attack of insects and other animals. Artificial reproduction, though difficult, is secured by direct sowing in lines, or by root and shoot cuttings of nursery-raised seedlings. The annual girth increment is 0.63–0.78 in. *L. pachyphyllus* is suitable for growing as a fuel and timber tree in tea estates in Darjeeling (Troup, III, 949: Macalpine, loc. cit.)

The wood is grey, moderately hard and heavy (wt., 50 lb./cu.ft.). It seasons well without warping or splitting, and is durable. It is used for planks, palings, shingles etc. It is a good fuelwood; calorific value: *sapwood*—4,854 cal., 8,738 B.t.u.; *heartwood*—4,935 cal., 8,884 B.t.u. (Gamble, 679; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 22).

The bark (tannin content, 22%) and acorns (tannin content of cups, 14–16%) are used for dyeing and tanning in Manipur; leaves contain 10–12% tannin. Bark and acorns are used medicinally as astringents (Badhwar *et al.*, loc. cit.)

L. spicatus (Sm.) Rehd. & Wils. syn. *Quercus spicata* Sm.

D.E.P., VI (1), 387; Fl. Br. Ind., V, 309.

BENG.—*Bara chakma*.

NEPAL *Arkaula*; ASSAM *Temi-sakho*.

A tree, 12 18 m. in height and 0.9–1.5 m. in girth with a bole 6–9 m. long, found in the Himalayas from Nepal eastwards, Assam hills and Manipur up to an altitude of 1,800 m. Bark grey, smooth; leaves very variable, oblong, oblanceolate or lanceolate; flowers monoecious or dioecious in spikes; nuts ovoid or conical, with saucer-shaped cupules which may be free or connate. The tree is commonly found in moist depressions, often gregariously; it coppices profusely (Troup, III, 949).

The wood is reddish brown, rough- and fibrous-grained, hard and heavy (wt., 56–63 lb./cu.ft.). It does not warp and is durable, especially under cover. It is used for building purposes, well construction, ploughs, mortars and helms of boats. It is also used as firewood and for making charcoal. Bark and wood contain, respectively, 10–14% and 6 9% tannin (Gamble, 680; Howard, 417; Burkill, II, 1858; Badhwar *et al.*, loc. cit.).

L. dealbatus (Hook. f. & Thoms.) Rehd. syn. *Quercus dealbata* Hook. f. & Thoms. is a shrub or small tree, found in Bhutan, Manipur, and hills of Assam up to an altitude of 1,800 m. The wood is reddish and hard: it is used as fuel. The bark contains 10–13% tannin [Bor, 122; Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 144].

L. lappaceus (Roxb.) Rehd. syn. *Quercus lappacea* Roxb. is a small or medium-sized tree found in Assam up to an altitude of 1,200 m. The wood is reddish, hard and heavy (wt., 56 lb./cu.ft.): it is suitable for cabinet work.

L. thomsonii (Miq.) Rehd. syn. *Quercus thomsonii* Miq. is a tree, 24–30 m. in height, found in Khasi hills between 600 and 1,500 m. The wood is used locally as fuel.

L. xylocarpus (Kurz) Markgraf syn. *Quercus xylocarpa* Kurz is a large tree with connate acorns found in Assam and Manipur up to an altitude of 2,100 m.

The nuts are eaten raw or roasted (Fl. Assam, IV, 318).

Lithographic Stones — *see* **Limestone**

LITHOSPERMUM Linn. (*Boraginaceae*)

A genus of annual, biennial or perennial herbs, subshrubs or rarely shrubs distributed mostly in America; a few have been recorded in Eurasia and Africa. Three species occur in India.

L. arvense Linn. CORN GROMWELL

Fl. Br. Ind., IV, 174; Chopra *et al.*, 705, Fig. 159.

A herbaceous, erect annual, 30–60 cm. high, found from Kashmir westward. Cauline leaves lanceolate, strigose, lower leaves petioled, obovate-oblong; flowers white, rarely bluish, in racemes; nutlets ovoid-oblong, pitted, acutely tubercled.

The plant contains an alkaloid, cynoglossine, with curare-like action, and possibly also a gluco-alkaloid, consolidine, which paralyses the central nervous system. The plant extract, leaf infusion and seeds are used in the same way as those of *L. officinale* (q.v.) (Watt & Breyer-Brandwijk, 153; Chopra *et al.*, 705; Kirt. & Basu, III, 1702; *Chem. Abstr.*, 1955, **49**, 12616).

The plant is used as fodder for camels and sheep in Baluchistan; it is suspected of poisoning stock in Australia. A red dye extracted from the roots and bark of the plant is used for colouring ointments, etc. (Burkill, 1909, 52; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 25; Jacobs & Burlage, 28).

L. officinale Linn. GROMWELL

D.E.P., V, 81; Fl. Br. Ind., IV, 175.

An erect, hispidly hairy perennial, 0.6–1.2 m. high, found in Kashmir and Kumaon at altitudes of 1,500–2,700 m. Leaves oblong-lanceolate, rough, strigose; flowers small, white, fading yellowish, in racemes; nutlets small, ovoid, white, smooth, shining.

The leaves of the plant contain: tannin (8%), fat (9%), rutin, a waxy ester (m.p. 80°) and β-sitosterol. An infusion of the leaves is used as sedative in Spain. The root is considered depurative; it contains a red pigment. A decoction of roots and twigs is given in the form of syrup in eruptive diseases, such as small-pox, measles and itch. The seeds are diuretic and lithontriptic; they are used as an electuary in gout and bladder diseases (Allen, VII, 363; *Chem. Abstr.*, 1925, **19**, 92; Davis & Ross, *Chem. & Ind.*, 1955, 1739; Kirt. & Basu, III, 1701; Roi, 266; Wehmer, II, 1018; Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37**, 531; Steinmetz, II, 302).

The nutlets, especially the pericarp (ash content, 29.3%), are rich in calcium carbonate and calcium silicate. The kernels (32.2% of the wt. of nutlet) contain (dry basis): fatty oil, 54.34; protein, 34.6; starch, 4.94; fibre, 2.78; and ash, 3.68%. The oil has the following characteristics: $n^{20°}$, 1.485; iod. val., 179.2; sap. val., 187.0; and R. M. val., 6.5 (Wehmer, II, 1018; *Chem. Abstr.*, 1940, **34**, 4931).

The aerial parts and roots of the herb contain a substance which inhibits the secretion of the pituitary gonadotropic hormone. Saline extracts administered to experimental animals by injection, inhibit oestrus and the functioning of ovaries and testes; the activity of the thyroid gland is also reduced. Oral administration is less effective. Properly prepared extracts of the herb are non-toxic and their use as human contraceptive has been suggested. The herb retains its activity at room temperature for one year; it is rapidly inactivated at 100° (*Chem. Abstr.*, 1955, **49**, 12713; 1953, **47**, 5544; *Nature, Lond.*, 1954, **174**, 215).

LITSEA Lam. (*Lauraceae*)

A large genus of dioecious trees or shrubs distributed chiefly in tropical and sub-tropical Asia to Australia and the Pacific Islands. About 43 species are found in India.

L. cubeba Pers. syn. *L. citrata* Blume

Fl. Br. Ind., V, 155.

NEPAL—*Siltimur*; LEPCHA—*Tanghaercherkung, terhilsok*; ASSAM—*Mejankeri*; KHASI—*Dieng-si-ing*; GARO—*Zeng-jil*; LUSHAI—*Sernam*.

A deciduous aromatic shrub or a small tree found in eastern Himalayas, Assam and Manipur up to an altitude of 2,700 m. Bark greenish, warty; leaves lanceolate or ovate-lanceolate, somewhat inequilateral, membraneous; flowers in umbels or corymbs; fruit globose.

Most parts of the plant are aromatic and yield volatile oils. The characteristics of oils from flowers, fruits, leaves and bark are given in Table 1. Flowers are reported to be employed in Tonquin for flavouring tea and for the extraction of an oil (May-Chang Oil) used in perfumery. It has a pleasing aroma suggestive of rose and coriander (Poucher, I, 265; Finnemore, 329).

Fruits are aromatic and yield on distillation a volatile oil with an odour reminiscent of verbena oil.

TABLE 1—CHARACTERISTICS OF VOLATILE OILS FROM LITSEA CUBEBA

Source	Flower[1,2]	Fruit[3,4]	Leaf[5,6]	Bark[5,7]
Yield (%)	..	4–5*	5.4	0.13–0.81
Sp. gr.	0.866 (at 20°)	0.867 (at 30°)	0.899–0.904 (at 15°)	0.866–0.906 (at 15°)
$[\alpha]_D$	+20.03°	+5.8°	12° to −1[illegible]	+10° to +21°
n	1.4620 (at 20°)	1.4702 (at 30°)	..	
Ester val.	7.65	6.72		230–252 (after acetylation)

[1] *Chem. Abstr.*, 1923, **17,** 1300. [2] The flower oil contains: citral, 8.1; free alcohols, 44.8; and esters, 2.7%; it contains geraniol, *d*-linalool, terpineol, limonene and traces of saturated aliphatic aldehydes (Finnemore, 329; Poucher, I, 265). [3] *Chem. Abstr.*, 1939, **33,** 1878. [4] The fruit oil contains: citral, 70; and methyl heptenone, 20%; small amounts of limonene, dipentene and linalool are present (*Chem. Abstr.*, 1939, **33,** 1878). [5] Gildemeister & Hoffmann, II, 499–500. [6] The leaf oil contains: cineol, 80; camphene, 4; α-terpineol, 7; and sesquiterpene, 1% (*Chem. Abstr.*, 1953, **47,** 5637). [7] The bark oil contains: citral, 8; citronellal, 10; geraniol(?), 56.5; and esters, 2.4% (Gildemeister & Hoffmann, II, 499–500). * Parry, I, 153.

The oil has recently gained importance in China as a source of citral (yield, usually 80%) and is reported to be particularly suitable for the production of methyl ionone. Citral and methyl ionone derived from the oil possess a finer odour than those produced from lemongrass oil (Gildemeister & Hoffmann, II, 499; *Perfum. essent. Oil Rec.*, 1959, **50,** 79).

The aromatic seeds yield 22% of a pale yellow fat (m.p. 40–42°) used for lighting purposes. The fat extracted from seeds of plants growing in India has the following characteristics: sp. gr.$^{35°}$, 0.911; $n^{40°}$, 1.4404; iod. val., 5.9; sap. val., 269.5; acid val., 0.6; and unsapon. matter, 1.7%; the component fatty acids are: lauric, 96.1; and oleic, 2.2%. The seed fat from plants growing in Formosa differs considerably in fatty acid composition; it contains: lauric, 53.2; capric, 22.9; myristic, 4.5; and unsaturated acids, 19.6% (Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37,** 752; Puntambekar, *J. Indian chem. Soc., industr. Edn*, 1938, **1,** 19; Narang & Puntambekar, *J. Indian chem. Soc.*, 1957, **34,** 135; *Chem. Abstr.*, 1940, **34,** 2625).

The leaves and bark of the plant also yield volatile oils (Table 1). Two alkaloids, laurotetanine ($C_{19}H_{21}O_4N.H_2O$, m.p. 125°) and methyl-laurotetanine ($C_{20}H_{23}O_4N$) have been isolated from the bark; the former is a powerful tetanic poison (Wehmer, suppl., 120; Manske & Holmes, IV, 125).

The tree is planted for shade in plantations in Indo-China. *Pat* silkworms are reared on the leaves of this tree in Assam. The wood (wt., 36 lb./cu.ft.) is grey and soft. The fruit is edible. It is aromatic and carminative and is reported to be used in Indo-China for headache, dizziness, hysteria, paralysis and loss of memory. It is also used as a preservative for fish. In Indonesia, the fruits are used as a substitute for cubeb pepper (*Piper cubeba* Linn.) (Crevost & Petelot, loc. cit.; Fl. Assam, IV, 81; Gamble, 570; Van Steenis-Kruseman, *Bull. Org. sci. Res. Indonesia*, No. 18, 1953, 27).

L. glutinosa (Lour.) C. B. Robins syn. *L. chinensis* Lam.; *L. sebifera* Pers.

D.E.P., V, 83; C.P., 544; Fl. Br. Ind., V, 157; Kirt. & Basu, Pl. 833 B.

Hindi—*Maida lakri, garbijaur*; Beng. *Kukur chita, garur, ratun*; Mar. *Maida lakadi*; Guj.—*Maeda lakari*; Tel.—*Narra alagi, naramamidi*; Tam. *Mushaippeyetti, elumpurukki, uralli*; Oriya —*Jaisanda*.

Punjab—*Meda sak, chandra, meda lakri*; Nepal—*Kawala*; Lepcha—*Suppatnyok*; Assam—*Heluka, bagnara*; Oudh—*Medh*; Madhya Pradesh—*Menda*.

An evergreen shrub or tree, up to 25 m. in height and 1.5 m. in girth, with a clean bole 6.0 m. long, found throughout India, ascending up to an altitude of 1,350 m. in the outer Himalayas. Bark brownish grey, somewhat corky, viscid inside; leaves very variable in size and shape, elliptic-ovate or oblong-lanceolate, pubescent, aromatic; flowers in umbellate heads, yellowish; fruit globose, black or purple.

The plant may be propagated by seed or by coppice shoots. It stands a fair amount of shade and grows fast; the recorded annual girth increment varies from 0.88 to 1.01 in. (Burkill, II, 1354; Troup, III, 797).

The wood is yellowish grey to greyish brown, generally with darker lines, lustrous when first exposed but becoming dull with age; heartwood not distinct; moderately hard, moderately heavy (sp. gr., c. 0.67; wt., 43 lb./cu.ft.), fairly straight-grained or somewhat

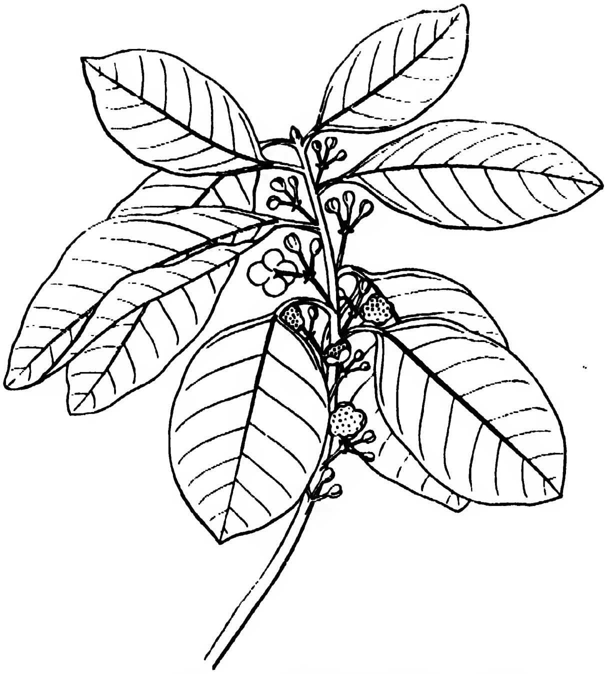


FIG. 51. LITSEA GLUTINOSA—FLOWERING BRANCH

wavy-grained in the radial plane, medium and even-textured. The timber seasons well; green conversion and slow drying of converted material are recommended. It is durable, works to a dull surface but takes a good polish. The wood is reported to be used for house building, furniture, packing cases, agricultural implements and oars. It is suitable for floor boards and ceilings, and packing chests; it does not stand extremes of wet and dry exposure (Pearson & Brown, II, 850–52; Lewis, 328; Macmillan, 215).

The bark of *L. glutinosa* constitutes the common demulcent drug sold in Indian bazars under the name Maida Lakri or Maida Lakadi. It is available in the form of broken quills or pieces, a few inches in length. It is mucilaginous, feebly balsamic and mildly astringent. It is used in diarrhoea and dysentery. Ground and pasted material is used as an emollient application for sprains, bruises and rheumatic and gouty joints; it is also used as a styptic dressing for wounds. Laurotetanine, tannin and a reddish brown colouring matter are present in the bark [Kirt. & Basu, III, 2159; Nadkarni, I, 748; Burkill, II, 1354; Dymock, Warden & Hooper, III, 211–13; Edwards *et al., Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 159].

The leaves are mucilaginous and considered emollient and antispasmodic. They are used in infusion or as poultice for bruises and wounds; flower buds are credited with similar properties. In parts of India, the leaves are used as cattle fodder (Kirt. & Basu, III, 2159; Burkill, II, 1354; Laurie, *Indian For. Leafl.*, No. 82, 1945, 9).

The fruit is edible. The seeds yield 35% of a fat with strong aromatic odour and disagreeable taste. It has the following characteristics: sp. gr.$^{30°}$, 0.919; $n^{30°}$, 1.4451; iod. val., 6.3; sap. val., 274.1; acid val., 4.5; and unsapon. matter, 1.25%. The component fatty acids are: lauric, 96.3; and oleic, 2.3%. The fat is used in China and Java for making candles and white soap. Refined and deodorized fat may be used for edible purposes. It is a rich source of lauric acid and may be utilized for the preparation of lauryl compounds used as detergents (Burkill, II, 1353–54; Williams, K.A., 285; Puntambekar, loc. cit.; Narang & Puntambekar, loc. cit.).

The root is sweetish bitter, astringent and tonic. In Philippines, a decoction of the root is used as emmenagogue (Kirt. & Basu, III, 2159; Quisumbing, 326).

L. monopetala (Roxb.) Pers. syn. *L. polyantha* Juss. D.E.P., V, 82; C.P., 1009; Fl. Br. Ind., V, 162; Kirt. & Basu, Pl. 834.

HINDI—*Meda, katmarra, patoia, kakuri*; BENG.—*Bara kukur chita*; MAR.—*Ranamba, rapamba*; TEL.—*Naramamidi*; TAM.—*Maidalagadil, muchaippe-yetti, picinbattaw*; ORIYA—*Baghoari, kulya, bastura.*

PUNJAB—*Rian, gwa, harein, meda lakri, karkawa*; NEPAL—*Ratmanti, kadmero*; LEPCHA—*Sunyok-kung, sapot-kung*; ASSAM—*Muga, hoanlu.*

A small to medium-sized tree, sometimes attaining a height of 21 m. and a girth of 1.8 m., found throughout North, East and central India and in Orissa and Circars up to an altitude of 1,200 m.; it is often planted for ornament. Bark dark grey or pale brown, exfoliating in corky scales; leaves elliptic-oblong, ovate or obovate, glossy, coriaceous; flowers in umbels or corymbs, white or pale greenish yellow; fruits globose-ellipsoid, black when ripe.

The tree is reported to be a fast grower, the recorded mean annual girth increment being 1.05–3.14 in. The wood is yellowish or olive-grey to brownish, turning dull and dark with age; it is fairly smooth, straight- or somewhat wavy-grained, medium-coarse and even-textured, moderately hard and light (sp. gr., c. 0.45; wt., 26 lb./cu.ft.) (Troup, III, 798; Pearson & Brown, II, 853–54).

The timber seasons well with negligible cracking, splitting and twisting, though discolouration and

decay are often observed. Conversion of logs immediately after felling and stacking in the open with adequate protection against white ant attack, gives good results. The wood is not durable and is readily attacked by fungi and insects: it is difficult to treat with an antiseptic. The wood is occasionally used for house building, furniture, oars and agricultural implements. It is used for tea boxes in Assam and Bengal and is considered suitable for internal construction and plywood. It is a good fuel wood; calorific value: *sapwood*—5,099 cal., 9,179 B.t.u. (Pearson & Brown, II, 854–55; *Indian For.*, 1948, **74,** 279: 1952, **78,** 277; Krishna & Ramaswami, *Indian For. Bull.*, *N.S.*, No. 79, 1932, 19).

The bark is mildly astringent and is reported to be used for diarrhoea. Powdered bark and roots are used in external applications for pains, bruises and contusions; they are also used for fractures in animals. The bark contains an irritant substance and tannin [Kirt. & Basu, III, 2160: Nadkarni, I, 748: Burkill, II, 1356; Edwards *et al.*, *Indian For. Rec.*, *N.S.*, *Chem. & Minor For. Prod.*, 1952, **1**(2), 159].

The leaves have a cinnamon-like odour when bruised; they are used as feed for *Muga* silkworms in Assam. They are also used as cattle fodder (Laurie, *Indian For. Leafl.*, No. 82, 1945, 9).

The seeds yield 21% of fat (yield from seed kernel, 33%) with the following characteristics: m.p. 38.5°; acid val., 98.9; sap. val., 244.8; and iod. val., 34.4: constituent glycerides: trilaurin, 97% and triolein, 2.6%. It is used for candle manufacture and also in ointments for rheumatism [Burkill, II, 1356; Rodger, 103; Krishna *et al.*, *Indian For. Rec.*, *N.S.*, *Chem.*, 1936, **1**(1), 38].

L. stocksii Hook. f.

Fl. Br. Ind., V, 176: Kirt. & Basu, Pl. 833A.

MAR.—*Pisi, posha*; MAL.—*Varikeera.*

A small or medium-sized tree found in the hills of western Deccan Peninsula up to an altitude of 1,800 m. Bark smooth, brown; leaves elliptic-oblong, coriaceous; flowers in umbels or racemes, yellowish white; fruit ellipsoid, dark purple when ripe; seed brown, oblong.

The leaves are mucilaginous: an infusion of leaves is given in irritations of bladder and urethra. The seeds yield 31.6% of a fat (m.p. 39°) consisting mostly of lauric acid with a small amount of oleic acid. It is applied to sprains and itches. The fruits contain a volatile oil. Laurotetanine is possibly present in the plant (Kirt. & Basu, III, 2162: Hooper, *Agric. Ledger*, No. 5, 1911–12, 161: Dymock, Warden & Hooper, III, 213).

L. angustifolia Hook. f. (ASSAM—*Tharham, dudhikhansau, khuwai-phang*; MANIPUR—*Haibru*) is a shrub or small tree found in Assam and Manipur. The wood is white or light brown and soft. Forked stems are locally used as buffalo yokes (Gamble, 572: Fl. Assam, IV, 88).

L. chartacea Hook. f. is a moderate-sized tree found in eastern Himalayas and Lushai hills in Assam. It is a good fuel wood; calorific value: *sapwood*—5,243 cal., 9,439 B.t.u. (*Indian For.*, 1948, **74,** 279; Krishna & Ramaswami, loc. cit.).

L. coriacea Hook. f. (TAM.—*Panni thali*; MAL.—*Maravetti thali*) is a small tree found in the Deccan Peninsula. The wood is used for fuel; it is also suitable for match boxes and splints (Bourdillon, 270: Rama Rao, 345).

L. deccanensis Gamble syn. *L. tomentosa* Heyne, non Blume (TAM.—*Perumbandali*; BOMBAY—*Kurak*) is a moderate-sized tree found in the hills of Deccan Peninsula between 600 and 1,800 m. The wood is yellow, wavy-grained, stringy, heavy and difficult to work. It is suitable for rafters, wall plates and tea boxes (Lewis, 327).

L. glabrata Hook. f. (TAM.—*Ongakanni*; MAL.—*Unkakanni*) is a tree found in the hills of South India at altitudes of 900–1,800 m. The wood (wt., 32 lb./cu.ft.) is pale olive-yellow, glossy, slightly mottled, smooth, moderately hard and resistant to insect attack; it can be used for planking and boxes (Bourdillon, 271).

L. lancifolia Hook. f. (NEPAL—*Kali pahenle, makai, kath*) is a shrub or small tree found in eastern Himalayas and Assam. The wood is suitable for construction purposes. The bark is reported to contain laurotetanine; it is used in poultices for sprains and wounds (Burkill, II, 1355).

L. nitida Hook. f. (NEPAL—*Lhopre*; ASSAM—*Kathalua, loban, supin-urn-rong*) is a moderate-sized or large tree found in eastern Himalayas, Bihar and Assam. The wood is used for posts (Fl. Assam, IV, 90).

L. salicifolia Hook. f. (NEPAL—*Sampat, sanupahenle*; LEPCHA—*Senashelkung*; ASSAM—*Digloti*; KHASI—*Dieng-lali*) is an evergreen shrub or small tree with very variable, lanceolate, elliptic or oblong leaves, found in north-eastern parts of India from Oudh to Assam, ascending up to an altitude of

2,000 m. in the Himalayas. The leaves are used as feed for *Muga* silkworms in Assam.

L. wightiana Hook. f. (Fl. Br. Ind.) in part (Bombay—*Kengi*; Nilgiris—*Kenju*) is a medium-sized or large tree found in the hills of Deccan Peninsula between 900 and 2,400 m. It yields a resin which is locally used as a substitute for frankincense.

The wood (wt., 46 lb./cu.ft.) is yellowish brown, shining and moderately hard. It is used for rafters and as fuel. The bark contains 6% tannin [Rama Rao, 346; Bourdillon, 270; Cameron, 230; Edwards *et al.*, *Indian For. Rec.*, *N.S.*, *Chem. & Minor For. Prod.*, 1952, **1**(2), 152].

Litsea spp. — *see* **Neolitsea**

Liver-flukes and other Flukes — *see* **Parasitic Worms**

Livestock — *see* **Supplement**

LIVISTONA R. Br. (*Palmae*)

A small genus of tall, graceful palms with fan-shaped leaves found in South-East Asia, Malaysia and Australia. One species is indigenous to India; a few others are grown for ornament.

L. australis Mart. Australian Fan Palm

Blatter, 107.

A tall palm, 12–24 m. high, native of Australia, cultivated in Indian gardens. Leaves orbicular, 0.9–1.2 m. diam., borne on spreading and decurved petioles; fruit globose, 1.8 cm. diam., with thick crustaceous pericarp.

Basal parts of young shoots of the palm are edible; consumed in excessive quantities, they cause internal complaints. The outer part of the stem is moderately hard; it is occasionally used for walking sticks and building slabs; hollowed trunk is used as pig trough. Leaves are used for baskets and the fibre obtained from unexpanded fronds is valued for making hats (Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 124; Firminger, 304; Gopalaswamiengar, 374; Blatter, 108–09).

L. chinensis R. Br. syn. *L. mauritiana* Wall.
Chinese Fan Palm

Fl. Br. Ind., VI, 434; Blatter, 104, Pl. XXVII

A fairly tall palm, 6–9 m. high, native of China and Japan, commonly cultivated in gardens in India and Andamans. Stem stout, obscurely annulate; leaves uniformly flabellate, 1.2–1.8 m. diam., with 50–60 segments.

This palm is perhaps the commonest and the most ornamental fan palm grown in Indian gardens. It is fairly frost-resistant and grows well throughout India. It can be easily propagated by seeds which are produced in great abundance (Benthall, 440; Gamble, 734–35; Firminger, 304).

The leaves of the palm are used for making fans. Fibrous sheaths of leaf stalks are made into ropes (Blatter, 106).

L. jenkinsiana Griff. Assam Fan Palm

D.E.P., V, 86; Fl. Br. Ind., VI, 435; Blatter, 101.

Assam—*Toko pat*; Lepcha—*Talainyom, tulacmyom, purbong.*

A graceful palm, 6–9 m. high, with thick round crown, commonly found in lower hills and outer valleys of Sikkim and throughout Assam, mostly in Nowgong district and Naga hills. Leaves 1.8–2.1 m. × 1.5–1.8 m., reniformly flabellate, divided into 70–80 segments: petiole spinous throughout; flowers small, clustered on small tubercles: drupe 1.8–2.5 cm. diam., lead-blue in colour.

This palm is commonly cultivated in gardens. It bears tough, light and durable leaves which are used for covering tops of *doolees* (palanquins) and roofs of boats, and for making hats. They are also used for thatching. Nuts have been tried for making buttons (Gamble, 734; Cowan & Cowan, 138; *For. Res. India*, 1952–53, pt II, 113).

L. rotundifolia Mart. syn. *L. altissima* Zoll.
Java Fan Palm

Blatter, 106–07; Brown 1941, I, 312.

A tall, erect, slender palm, 12–15 m. high, native of the Philippines and Malaya, and grown in India for ornament. Leaves 0.9–1.5 m. diam., sub-orbicular, palmatifid with 30–90 segments; petiole 1.8 m. long, compressed spines in lower part; flowers in aggregates of 3–4, globose, yellow; fruit globular.

This is one of the most handsome palms cultivated in gardens. The cellular tissue in the central part of the stem furnishes sago. A gum exudes from injured parts of the trunk. The leaves are used for packing in some parts of Indonesia. They are used also for thatching, boat-sails, raincoats and hats. Buds are edible and esteemed as a vegetable; fruits are eaten by animals and birds (Blatter, 107; Benthall, 441; Brown, 1941, I, 312; Burkill, II, 1358; Fox, *Philipp. J. Sci.*, 1952, **81**, 335).

The trunk of this palm is sometimes used in Philippines as pillars in houses; it takes a beautiful finish and lasts well when not exposed to dampness. It is used for walking sticks and golf sticks. The outer part of the trunk is stripped and used as floor covering (Burkill, II, 1358; Brown, 1941, I, 312).

LIZARDS (Class *Reptilia*, order *Squamata*, sub-order *Lacertilia*)

D.E.P., VI (1), 428–35; Fn. Br. Ind., Reptilia and Amphibia, 1935, II, 440 pp.

Lizards, of which about 2,500 species are reported, constitute one of the dominant groups of the present day reptiles. They are cosmopolitan in distribution but are more common in the tropics. About 250 species belonging to 8 families occur in India.

Lizards exhibit great variety in shape, size and structure. The majority of these are terrestrial; arboreal, burrowing and aquatic forms are not uncommon. Terrestrial forms are rather depressed, while arboreal and aquatic forms are compressed from side to side; burrowing or subterranean forms are usually cylindrical and elongated and sometimes limbless. Lizards are usually protectively coloured and the skin is normally covered with a layer of horny scales, often underlain by bony plates. The limbs are generally well developed and climbing lizards are equipped with adhesive pads. Many of the lizards can break their tails at will; the broken segment retains its muscular irritability for some time thereby distracting the attention of the pursuer and enabling the lizard to escape.

Most lizards are oviparous; a few viviparous species are also known. The food usually consists of insects, worms and other small animals; some species are almost exclusively vegetarian. With the exception of some Mexican species, lizards are non-poisonous. The flesh of many species is eaten and some lizards are believed to possess medicinal virtues. The skins of about two dozen species are tanned and the leather used for fancy apparel, shoes, slippers and household articles (Regan, 341–42; Thomson, 741–42; Pycraft, 529–32; Encyclopaedia Britannica, XIV, 244; d'Abreu, *J. Bombay nat. Hist. Soc.*, 1932–33, **36,** 269; Reese, 177; Pagnon, *J. Leath. Technol. Ass. India*, 1957, **5,** 227).

Of the lizards found in India, the geckoes (*Gekkonidae*), agamids (*Agamidae*) and scincids or skinks (*Scincidae*) are the most numerous; chameleons (*Chamaeleonidae*) and dibamids (*Dibamidae*) are represented by a single species each, lacertids (*Lacertidae*) by about ten species, anguids or glass snakes (*Anguidae*) by one or two species, and varanids or monitors (*Varanidae*) by four species.

Gekkonidae—The geckoes are nocturnal, soft-skinned lizards with adhesive expansions on their dilated digits, well adapted for ascending walls and crawling on ceilings. *Hemidactylus brooki* Gray, the common member of the family, is the house gecko or wall lizard (Sans.—*Musali, sarata*; Hindi—*Chipkili*; Beng.—*Tiktiki*; Tel.—*Ballie*; Tam.—*Pallie*). Other members of the family found in India, some of which are known by the same vernacular names, include: the red gecko (*H. maculatus* Dum. & Bibr.), a large species found in South India and Bombay; Prashad's gecko (*H. prashadi* Smith), recorded from North Kanara; bridled gecko (*H. frenatus* Schlegel), found in South India and Bengal; *H. flaviviridis* Ruppel, common in Bombay and North India; *H. leschenaulti* Dum. & Bibr., said to be cannibalistic, frequenting trees throughout India; fat-tailed lizard (*Eublepharis hardwickii* Grey), recorded from Bengal, Bihar, Orissa, Madras, Madhya Pradesh and Uttar Pradesh; and *Gekko gecko* Linn., the common gecko, found in Bihar, Bengal and the Andamans.

FIG. 52. WALL LIZARD—HEMIDACTYLUS BROOKI

Agamidae—Agamids are exclusively Old World lizards with ornamental appendages, e.g. crests and gular sacs; they exhibit a great variety of colour patterns. The skin is devoid of bony plates and the tail is usually long, but not fragile. The more

important representatives of the family found in India are: flying lizard (*Draco* spp.), arboreal in habit with gaily coloured wing-like membranes which enable the lizard to glide from tree to tree; fan-throated lizard (*Sitana ponticeriana* Cuvier) which when excited unfolds and folds its gular appendages with such great rapidity as to give the effect of flickering light sparks; blood-sucker (*Calotes* spp.); *Agama tuberculata* Gray, distributed in the barren rocks of Simla, Mussoorie and Naini Tal; *Psammophilus dorsalis* (Gray), found at high altitudes in South India; and spiny-tailed lizard (*Uromastix hardwickii* Gray), inhabiting deep burrows in sandy places of N.W. India and Uttar Pradesh. The last named lizard can be tamed; its flesh is reported to be eaten by some tribal people. The fat is used as an embrocation; hibernating lizards are dug out and used medicinally for horses.

Chamaeleonidae—Chameleons are characterized by the possession of a prehensile tail, independently movable eyes, a long protrusible tongue, feet modified into grasping organs and power to change the colour of their skin. The family is represented in India by *Chamaeleon zeylanicus* Laurenti (Indian Chameleon), occurring in the forests of Peninsular India, south of the Gangetic plain.

Scincidae—Scincids or skinks are the most numerous among the lizards and are cosmopolitan in distribution. They are mostly terrestrial; limbs may or may not be present and show all stages of reduction and loss of digits. Some scincids live beside streams and sea shores and take freely to water. Burrowing scincids are numerous and show progressive reduction of eyes and concealment of ears. The family is represented in India by several species belonging to

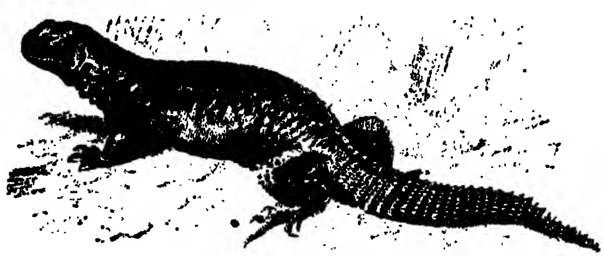


FIG. 53. SPINY-TAILED LIZARD—UROMASTIX HARDWICKII

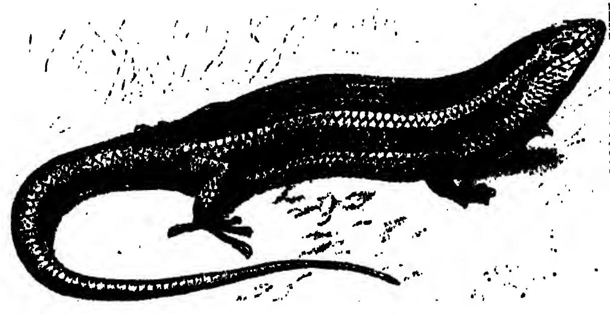


FIG. 54. COMMON INDIAN SKINK—MABUYA CARINATA

the genera *Mabuya* Fitzinger, *Lygosoma* Hardwicke & Gray, *Leiolopisma* Dum. & Bibr., *Riopa* Gray, *Ristella* Gray, etc.

Mabuya carinata (Schneider), the common Indian skink (MAR.—*Surpa chi mousi*; PUNJAB—*Reg-mahi*), is found almost throughout India, up to an altitude of 2,500 m., frequenting deserted houses and loose rocky soils; it is also found on trees. A medicinal oil is extracted from the lizard.

Varanidae—Varanids or monitors, confined to the warmer parts of the Old World, are the largest among living lizards, reaching up to 3 m. in length. Four species, all of them carnivorous, are found in India. With the exception of *Varanus griseus* (Daudin) all Asian species are good climbers. *V. monitor* (Linn.) and *V. salvator* (Laurenti) are reported to eat melons, cucumbers and ears of paddy; at times they are destructive to poultry.

V. monitor (Linn.), the common Indian monitor (SANS.—*Ghodasala, gandhera*; HINDI & BENG.—*Ghosanp*; MAR.—*Gor pade*; TEL. & TAM.—*Udumbu*; MAL.—*Biyawak, manawak*), is found throughout the plains of India, ascending up to an altitude of 1,800 m. in the Himalayas. It is diurnal in habit and lives in burrows and cracks on the ground; it is sometimes found on the roofs of less frequented houses. The lizard is brownish or olive above, usually with blackish dots, and yellowish below. The body usually measures *c.* 75 cm. in length and the tail, *c.* 100 cm. although much larger lizards are sometimes met with. The species is hunted with the help of dogs for its skin and flesh. The skins are used by some tribes for drums and fiddles; flesh and eggs are eaten. An electuary prepared from the body of the lizard is used in consumptive complaints. The distribution of nitrogen in the dried flesh of *V. monitor* is as follows: amide, 0.847; humin, 0.193; arginine, 10.42; histidine, 13.61; cystine, 7.81; lysine, 3.77; monoamino N, 26.58; and nonamino

N, 36.21 mg./g. (Airan & Ghatge, *Indian J. med. Res.*, 1950, **38**, 417).

V. salvator (Laurenti), the common water monitor (GARO—*Aringga, matphy, phusil*), occurs in rivers and streams in the eastern Himalayas up to an altitude of 1,800 m. It is more frequent near Simsang and Someswari rivers in Garo hills and in Sunderbans, and is seldom found away from water. The adult is dark olive in colour with indistinct yellow spots. The body measures up to 100 cm. in length and the tail up to 150 cm. The depot fat of the lizard is used in cutaneous troubles. It is a golden yellow liquid with the following characteristics: sap. equiv., 283.9; iod. val., 70.8; acid val., 4.5; and unsapon. matter, 1.6%. The component acids of the fat are: myristic, 4.2; palmitic, 29.3; stearic, 9.8; and unsaturated acids (C_{16}, 12.3; C_{18}, 39.6; and C_{20}, 4.8), 56.7% (Hilditch & Paul, *Biochem. J.*, 1937, **31**, 227).

The other two species of monitors found in India are *V. griseus* (Daudin), the desert monitor, living in burrows in the sandy regions of N. W. India and *V. flavescens* (Gray), found from Punjab to West Bengal. The former is greyish brown or yellowish brown, while the latter is yellowish, developing broad red cross bands during the rainy season (Trench, *J. Bombay nat. Hist. Soc.*, 1911–12, **21**, 687; Venning, ibid., 1911–12, **21**, 690; Baini Prashad, ibid., 1914–15, **23**, 370; 1915–16, **24**, 834; Gill, ibid., 1923–24, **29**, 303; Jouguet, ibid., 1928–29, **33**, 452; Asana, ibid., 1930–31, **34**, 1041; Smith, ibid., 1931–32, **35**, 615; Das, ibid., 1931–32, **35**, 660; Parry, ibid., 1931–32, **35**, 903; Seshaiya, ibid., 1938–39, **40**, 132; McCann, ibid., 1939–40, **41**, 742; 1940–41, **42**, 45; Battye, ibid., 1942–43, **43**, 530; Bhaduri, ibid., 1943–44, **44**, 130; Regan, 342–68; Pycraft, 532–46; d'Abreu, loc. cit.).

Trade—The skins of the common Indian monitor, desert monitor and *V. flavescens* are collected for export; the skin of *V. salvator* is of fine texture and commands a high price, but is rather scarce. The skins are graded for export purposes according to colour, pattern, texture and quality. U.S.A., U.K. and France are the main importing countries. Table 1 gives the quantity and value of undressed and dressed lizard skins exported from India.

TABLE 1—EXPORTS OF LIZARD SKINS

	Undressed		Dressed	
	Qty (cwt.)	Val. (Rs.)	Qty (cwt.)	Val. (Rs.)
1957	6,268	25,10,181	165	1,29,251
1958	5,815	15,27,450	253	1,06,376
1959	5,967	18,52,898	641	3,43,060
1960*	5,690	17,49,546	527	3,11,128

* April 1960 to March 1961.

LOBELIA Linn. (*Campanulaceae; Lobeliaceae*)

A large genus of herbs, subshrubs or shrubs distributed mostly in tropical and sub-tropical regions; a few species are found in temperate and even frigid zones. About 20 species occur in India and some exotics are grown in gardens.

L. inflata and *L. nicotianaefolia* yield the drug Lobelia.

L. chinensis Lour. syn. *L. radicans* Thunb.

Fl. Br. Ind., III, 425.

A procumbent glabrous herb found in Nepal, Chota Nagpur and Khasi hills at altitudes of 900–1,500 m. Leaves sessile, linear or oblong-lanceolate; flowers small, green with pink marks, axillary; capsules small with ellipsoid, slightly compressed seeds.

The plant is used in China for fevers and asthma. The root is considered depurative and antirheumatic in Indo-China. The rhizomes of the plant are reported to contain the polyfructosan, lobelinin $(C_6H_{10}O_5)_8$ (Roi, 422; Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37**, 274; *Chem. Abstr.*, 1951, **45**, 8600).

L. inflata Linn.

D.E.P., V, 86; Bailey, 1949, 971; Bentley & Trimen, III, Fig. 162.

An erect annual herb, 30–90 cm. high, indigenous to eastern United States and Canada. Leaves oval or ovate-lanceolate, pubescent, denticulate; flowers small, light blue, in terminal and axillary racemes; capsules inflated, sub-globular, 5–8 mm. long, compressed laterally; seeds numerous, minute, ovate-oblong, coarsely reticulate, brown.

L. inflata is the chief source of the drug, Lobelia. It does not occur in India, but has been grown in Darjeeling, though not on a commercial scale. Its cultivation has been recommended in eastern Himalayas, Nilgiris and Kerala at altitudes of 900–2,100 m. The drug is imported into India from America; data relating to imports are not available (Nayar & Chopra, 35–36; Krishnamurthi, 146; Bal & Gupta, *Bull. nat. Inst. Sci. India*, No. 4, 1955, 109).

The plant thrives in rich moist loam in the open or in partial shade. Seed is sown in well prepared

ground in rows 30 cm. apart: sometimes seeds are sown in beds and seedlings transplanted in the field. Leaves and flowering tops are collected when the plants are in flower and the lowermost capsules have become inflated. They are dried in shade and compressed into rectangular cakes weighing 250–500 g. and wrapped in paper for export. Commercial supplies of the drug come mostly from U.S.A. (New York, Massachusetts and Michigan) [Sievers, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1999, 1948, 65; Wallis, 306; U.S.D., 1955, 767; Lloyd & Lloyd, *Bull. Lloyd Libr., Reprod. Ser.*, 1931, **2** (9), 63.].

The drug (Lobelia, Lobelia Herba, Indian Tobacco) was formerly official in B.P. and U.S.P. It contains: stems, $\ngtr$60; acid insoluble ash, $\ngtr$5; foreign organic matter, $\ngtr$2; and total alkaloids (as lobeline), $\nless$0.3%. It has a slightly irritating odour and a burning acrid taste similar to that of tobacco. It is expectorant and is administered in asthma and chronic bronchitis to relieve spasm. When swallowed in small doses, it produces severe vomiting, nausea, copious sweating and great general relaxation. The symptoms are greatly accentuated when taken in toxic doses; in addition to burning pain in fauces or oesophagus, there is progressive failure of voluntary motion, rapid and feeble pulse, fall of temperature and finally collapse with stupor or coma; in some cases, convulsions precede death. Poisonous symptoms usually appear when the drug is not rejected by vomiting. Treatment consists in evacuating the stomach and treating the symptoms (U.S.D., 1955, 768–69; B.P.C., 1959, 411–12).

The drug owes its activity to the presence of a number of alkaloids, of which lobeline is the major component (3–50%). The total alkaloid content varies from 0.13 to 0.63%, av., 0.4%, depending on the conditions of growth and the time of harvesting the plant. The maximum concentration of alkaloids is reached in plants at the middle of the blossoming period. The distribution of lobeline in different parts of the plant is reported as follows: blossoming apex, 0.9–1.1; unripe capsule, 0.88–1.05; leaves, 0.42–0.43; stems, 0.35–0.38; and roots, 0.54–0.56% (U.S.D., 1955, 768; Manske & Holmes, I, 189; *Chem. Abstr.*, 1940, **34**, 4227).

The alkaloids of lobelia (Table 1) are piperidine derivatives and may be classified into three groups, viz. lobeline, lelobine and lobinine; the last two groups include only minor alkaloids. Lobeline, the most active alkaloid of the drug, is similar to nicotine in action but weaker. Like nicotine, it acts on the central nervous system, autonomic ganglia and the nerve ends in voluntary muscles; it is a primary stimulant and a secondary depressant. The secondary alkaloids have effects probably similar to lobeline, but are less potent. *Iso*lobinine possesses emetic and spasmolytic properties (Henry, 22–34; Hale-White, 282; U.S.D., 1955, 768–69).

TABLE 1—ALKALOIDS ISOLATED FROM L. INFLATA*

	Molecular formula	M.p.
Lobeline group:		
l-lobeline	$C_{22}H_{27}O_2N$	130–31°
dl-lobeline	$C_{22}H_{27}O_2N$	110°
lobelanine	$C_{22}H_{25}O_2N$	99°
*nor*lobelanine	$C_{21}H_{23}O_2N$	120–21°
lobelanidine	$C_{22}H_{29}O_2N$	150°
*nor*lobelanidine	$C_{21}H_{27}O_2N$	120°
Lelobine group:		
dl-lelobanidine	$C_{18}H_{29}O_2N$	68°
l-lelobanidine I	$C_{18}H_{29}O_2N$	86° (B.HCl. 2 H_2O)
l-lelobanidine II	$C_{18}H_{29}O_2N$	102–05° (B.HCl. 1.5 H_2O)
*nor*lelobanidine	$C_{17}H_{27}O_2N$	90°
Lobinine group:		
lobinine	$C_{18}H_{25}O_2N$	144° (B.HCl)
*iso*lobinine	$C_{18}H_{25}O_2N$	78°
lobinanidine	$C_{18}H_{27}O_2N$	95°
*iso*lobinanidine	$C_{18}H_{27}O_2N$	111° (B.HCl)

* Henry, 23–31.

Lobeline is considered a respiratory stimulant and has been used in respiratory failure resulting from anesthesia, poisoning by narcotics and noxious gases and similar conditions. It finds application in the measurement of blood circulation rates. It is given in resuscitation of the new born, but such use is considered dangerous. It is reported to be useful in certain cases of urticaria. Lobeline is used in the form of hydrochloride or as sulphate. Lobeline hydrochloride is official in Indian Pharmacopoeia and is administered subcutaneously. Formulations containing lobeline sulphate and B-vitamins or antacid compositions are used as deterrents for tobacco habit (Cushny, 437; Datta & Bal, *Sci. & Cult.*, 1944–45, **10**, 260; U.S.D., 1955, 769; I.P., 371; Modern Drug Encyclopedia, 481; *Chem. Abstr.*, 1952, **46**, 9267; 1955, **49**, 9890).

The seeds of *L. inflata* contain lobeline and are used as expectorant and as a remedy for asthma. They yield 30% of a drying oil. Commercial supplies of seeds are sometimes adulterated with mullein seeds (*Verbascum thapsus* Linn.) (Steinmetz, II, 281 ; Gathercoal & Wirth, 434).

L. leschenaultiana (Presl) Skottsb. syn. *L. excelsa* Lesch.

Fl. Br. Ind., III, 427 ; Fyson, II, Pl. 304.

A tall biennial herb with acrid, milky juice found in hills of South India at altitudes above 1,800 m. Leaves oblanceolate, obovate or elliptic, very large at base, finely toothed ; flowers white or pale yellow tinged with purple, in terminal dense spikes ; fruits globular, enclosed in calyx tube.

The leaves are cured and smoked as tobacco. They are reported to possess insecticidal properties. An infusion suitable for spraying is prepared by curing the leaves in shade and soaking in water for 12 hr. ; a small quantity of soap is added to the filtered solution before use. *L. leschenaultiana* infusions are used in the control of aphids, tingids and mites on vegetable and other crops. The plant is poisonous to man and livestock (Chopra *et al.*, 600, 47 ; *Mem. Dep. Agric. Madras*, No. 36, 1954, 1020).

The acrid latex of the plant causes dermatitis. Analysis of latex gave the following values: caoutchouc, 1.62 ; resins, 4.9 ; ash, 1.2 ; and N, 0.26%. Sheet rubber (caoutchouc, 9.69 ; resins, 27.1 ; ash, 3.1 ; and N, 1.55%) prepared from the latex had poor elasticity and was extremely tacky (Chopra *et al.*, 40 ; Siddiqui & Warsi, *J. Indian chem. Soc., industr. Edn*, 1945, **8,** 63).

L. nicotianaefolia Heyne
Pl. 567A.

D.E.P., V, 86 ; Fl. Br. Ind., III, 427 ; Kirt. & Basu,

SANS.—*Devanala* ; HINDI—*Nala, narasala* ; BENG.—*Badanala* ; MAR.—*Devanala, thoradevanala, dhaval* ; GUJ.—*Nali* ; TEL.—*Adavipogaku* ; TAM.—*Kattuppugaiyilai, upperichedi* ; KAN.—*Kaduhogesoppu, kandele* ; MAL.—*Kattupokala, kattupukayila.*

A large biennial or perennial herb, 1.2–3.6 m. high, found in Deccan, Konkan and western ghats at altitudes of 900–2,100 m. Stem stout, hollow, branched at top : leaves oblong or oblong-lanceolate : lower leaves large, upper ones gradually smaller ; flowers large, white tinged with lilac, in long terminal racemes or spikes ; capsules sub-globose, 8 mm. in diam. ; seeds very small, numerous, ellipsoid, compressed, yellowish brown, extremely acrid.

L. nicotianaefolia is a rich source of alkaloids of the lobeline group and used as a substitute for *L. inflata.* The total alkaloid content of dried stems and flowering tops, collected during September–November from Poona, Madras and Tellicherry (Kerala), ranges from 1.04 to 1.18% (calculated as lobeline) ; samples gathered during rains contain less (0.32%). Flowering tops contain the highest concentration followed by leaves and stems. Lobelanidine is reported to be the principal alkaloid ; *l*-lelobanidine and 3 unidentified bases are present. Recent analyses of *L. nicotianaefolia* grown in Maharashtra State show that the plant contains appreciable quantities of *nor*-lobelanine and small amounts of lobinine and minor bases (Mukerji & Ghosh, *Curr. Sci.*, 1945, **14,** 198 ; *Chem. Abstr.*, 1954, **48,** 10035 ; Handa & Nazir, *J. Instn Chem. India*, 1960, **32,** 146).

Aerial parts of *L. nicotianaefolia*, collected in October–November and dried in shade, constitute the drug Lobelia or Lobelia Herba official in the Indian Pharmacopoeia. The drug has an extremely acrid and nauseating taste and is almost odourless. It should contain: foreign organic matter, $\not>2$; ash, $\not>5$; acid-insoluble ash, $\not>2$; and total alkaloids (as lobeline), $\not<0.8\%$. *L. nicotianaefolia* is often adulterated with, or substituted by, *L. pyramidalis* Wall., *Eclipta alba* (Linn.) Hassk., *Laggera aurita* Sch.-Bip. and *Verbascum thapsus* Linn. (Datta & Bal, *Sci. & Cult.*, 1944–45, **10,** 260 ; Mukerji & Ghosh, loc. cit. : I.P., 369–70 ; I.P.C., 141 ; Bal & Gupta, *Bull. nat. Inst. Sci. India*, No. 4, 1955, 109).

The whole plant, when dry, is studded with small spots of resinous exudation, which is hot and acrid to the taste. Leaves and aerial parts of the plant exude a white latex which causes dermatitis. The plant is poisonous and used as an antiseptic. In Ceylon, it is used as an insecticide. The seeds contain an acronarcotic poison. The symptoms of poisoning by leaves and seeds are similar to those of nicotine ; the burning pain in the stomach is more severe ; death is caused by paralysis of respiration (Chopra *et al.*, 602, 40 ; Macmillan, 459 ; Nayar, *J. Bombay nat. Hist. Soc.*, 1954–55, **52,** 516).

L. alsinoides Lam. syn. *L. trigona* Roxb. (SANTAL—*Chauric arak* ; MUNDARI—*Hendegel ba*) is a glabrous annual herb, 30 cm. high, found in rice fields and moist situations in upper Gangetic plain, Nepal, Bihar, Chota Nagpur, West Bengal, Assam, Deccan, Konkan and S. India up to 1,800 m. The leaves are used as pot-herb in Chota Nagpur ; in Bombay, they

are eaten in times of scarcity [Gammie, *Rec. bot. Surv. India,* 1902, **2**(2), 183].

L. pyramidalis Wall. (LUSHAI—*Berawchal*) is an erect herb, 0.3–2 m. high, with linear-lanceolate leaves and white or purple rose flowers in racemes found in the Himalayas from Kumaon eastwards to Sikkim and Aka, Lushai and Khasi hills in Assam at altitudes of 900–2,700 m. The dried leaves and flowering tops of the plant contain 0.29–0.38% alkaloids (as lobeline) and may be used as a substitute for *L. inflata* (Datta & Datta, *J. sci. industr. Res.,* 1951, **10B,** 218).

Ornamental *Lobelia* spp. grown in Indian gardens for their beautiful flowers include: *L. cardinalis* Linn. (CARDINAL FLOWER), *L. cordigera* Cav. (syn. *L. fulgens* Willd.), *L. erinus* Linn. and *L. succulenta* Blume (syn. *L. affinis* Wall.). *L. cardinalis* contains 0.445% alkaloids with lobinaline ($C_{28}H_{38}ON_2$, m.p. 94–95°) as the main component. Lobinaline depresses blood pressure but has no influence on respiration. *L. cordigera* contains inulin (Firminger, 472; Gopalaswamiengar, 171, 443–44; Manske & Holmes, I, 189, 204, 206; *Chem. Abstr.,* 1939, **33,** 3528; Wehmer, II, 1209).

Lobsters — *see* **Prawns, Shrimps and Lobsters**

LOBULARIA Desv. (*Cruciferae*)

Fl. Br. Ind., I, 41; Chittenden, III, 1198.

A small genus of annual to perennial herbs native of the Mediterranean region. One species is grown in Indian gardens.

L. maritima (Linn.) Desv. syn. *Alyssum maritimum* Lam. is a dwarf, much-branched annual, 7.5–25 cm. high, with linear-lanceolate leaves, small, white, fragrant flowers, and orbicular-ellipsoid pods. It is grown in gardens in northwest India, northern Bihar and West Bengal as a cold season annual. It is propagated by seeds and is suitable for garden borders, edging large plants, carpet beds and hanging baskets. It is reported to be a good bee-plant. The plant is considered antiscorbutic and diuretic in Spain (Gopalaswamiengar, 406; Chittenden, III, 1198; Caius, *J. Bombay nat. Hist. Soc.,* 1938–39, **40,** 695).

LOCHNERA Endl. (*Apocynaceae*)

A small genus of herbs distributed in Madagascar and India. Two species are found in India of which *L. rosea,* an exotic species, is commonly grown in gardens.

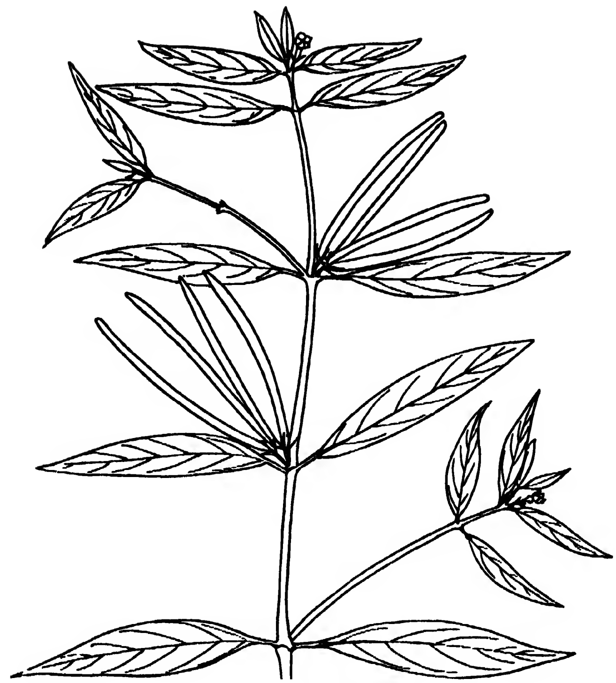


FIG. 55. LOCHNERA PUSILLA—FLOWERING & FRUITING BRANCH

L. pusilla (Murr.) K. Schum. = *Catharanthus pusillus* G. Don syn. *Vinca pusilla* Murr.

D.E.P., VI (4), 243; Fl. Br. Ind., III, 640.

SANS.—*Sangkhi, sangkhaphuli;* TAM.—*Milagai poondu;* MAL.—*Kapavila.*

DELHI—*Teanklo;* BOMBAY—*Sankaphi;* MUNDARI—*Marchi ara, laba ba.*

A herbaceous erect, much-branched annual, 15–60 cm. high, found in western Himalayas, upper Gangetic plain, Bihar, Orissa, plains of Circars, Deccan, Gujarat, Maharashtra and South India; it occurs usually as a weed in cultivated fields and pastures. Leaves opposite, lanceolate, acuminate; flowers axillary, white, solitary or in pairs; follicles slender.

The plant is reported to be toxic, particularly to cattle, causing temporary blindness with urticarial rashes all over the body. A decoction of the dried plant boiled in oil is rubbed in lumbago. The leaves are said to be eaten as pot-herb (Chopra, *J. sci. industr. Res.,* 1952, **11A,** 241; Kirt. & Basu, II, 1560; Bressers, 91).

LOCHNERA ROSEA — FLOWERING & FRUITING BRANCHES

The plant contains two alkaloids, pusiline (m.p. 294–95° decomp.) and pusilinine (m.p. 250–52° decomp.), both of which cause marked depression of the heart. Three sterols (m.p. 158–59°, 141–42° and 76–77°) have also been isolated (Majumdar & Paul, *Indian J. Pharm.*, 1959, **21,** 255).

L. rosea (Linn.) Reichb. = *Catharanthus roseus* G. Don syn. *Vinca rosea* Linn. MADAGASCAR PERIWINKLE, RED PERIWINKLE

D.E.P., VI (4), 244; Fl. Br. Ind., III, 640.

HINDI—*Sadabahar;* BENG.—*Nayantara, gul feringhi;* MAR.—*Sadaphul;* TEL.—*Billaganneru;* TAM.—*Sudukadu mallikai;* MAL.—*Ushamalari;* ORIYA—*Ainskati.*

PUNJAB—*Rattanjot.*

An erect annual or perennial herb, 0.3–0.9 m. high, native of Madagascar, now naturalized throughout the tropics of both hemispheres. Leaves opposite, oval, obovate or oblong, glossy; flowers usually 2–3, in cymose axillary clusters; fruit a cylindrical follicle, many-seeded. Three cultivars of *L. rosea* are recognized: 'Alba' with white flowers, 'Ocellata' with corollas white with rose pink to carmine-red eye, and 'Roseus' with uniformly rose coloured flowers (Lawrence, *Baileya*, 1959, **7,** 113).

L. rosea is commonly grown in gardens. It is propagated by seeds or cuttings and is suitable for summer bedding, borders and rockeries; it is also grown in large masses in parks. The plant is sometimes found as an escape in waste places and sandy tracts. It blooms almost throughout the year and should be cut back every four months as it becomes woody and straggling otherwise (Bailey, 1947, III, 3471; Gopalaswamiengar, 467; Bor & Raizada, 201; Williams & Williams, 209).

The plant is subject to a virus disease showing symptoms of mosaic mottling, phyllody, rosette and green vein banding; it is also subject to a disease similar to the spike disease of sandal, resulting in a bushy appearance accompanied by diminution in leaf size and nodal distance. *L. rosea* is susceptible to damping off disease due to *Phytophthora parasitica* Dastur in the wet season; growing points, leaves, flowers and fruits are affected. Both white and pink flowering varieties are affected by *Fusarium* wilt; *F. solani* (Mart.) App. & Wr. and *F. scirpi* affect the white variety; the causal organism for the pink variety has not been identified (Joshi, H. U., Unpublished Thesis, Indian agric. Res. Inst., 1953; Iyengar, *J. Indian Inst. Sci.*, 1935, **18A,** 61; Dastur, *Mem. Dep. Agric. India, Bot.*, 1916, **8,** 233; Sinha & Chauhan, *Proc. Indian Sci. Congr.*, 1959, pt III, 341).

The plant has been used as a folk remedy for diabetes in Natal and various other parts of S. Africa and also in India and Ceylon. It is reported to be toxic to cattle. The juice of the leaves is used as an application for wasp stings. An infusion of the leaves is given in the treatment of menorrhagia. The root is considered toxic and stomachic (Watt & Breyer-Brandwijk, 143–44; Kirt. & Basu, II, 1559–60; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 18).

All parts of the plant, particularly the root bark contain alkaloids (Table 1); these include three alkaloids of the *Rauvolfia* group, viz. ajmalicine, serpentine and reserpine; the concentration of the first two alkaloids is greater in the roots of *L. rosea* than in the roots of *Rauvolfia serpentina* Benth. ex Kurz. The alkaloids of *L. rosea* are listed in Table 2 [Pillay *et al., Bull. Res. Inst., Univ. Kerala,* 1957, **5A** (1), 65; 1959, **6A** (1), 51; Svoboda *et al., J. Amer. pharm. Ass., sci. Edn*, 1959, **48,** 659].

L. rosea alkaloids possess hypotensive, sedative and tranquillizing properties similar to, but more marked than, those of the total alkaloids of *Rauvolfia serpentina*. They also cause relaxation of plain muscles and depression of the central nervous system. They inhibit the growth of *Vibrio cholerae* and *Micrococcus pyogenes* var. *aureus,* but possess no anti-bacterial action against the enteric group of organism. Vindoline and other alkaloidal fractions from the leaves are active against *M. pyogenes* var. *aureus* and var.

TABLE 1—ALKALOID CONTENT OF DIFFERENT PARTS OF LOCHNERA ROSEA

	Total alkaloids		
	Pink-flowered variety %		White-flowered variety %
Roots[1] (Jammu)	1.08		1.34
Leaves[1] (do.)	0.82		0.74
Stems[1] (do.)	0.36		0.17
Roots[2] (do.)		1.18[a]	
Roots[3] (Travancore)		1.22[a]	
Root bark[3] (do.)	9.0[b]		..

[a] Variety not indicated; [b] root bark from white-flowered variety contained half this amount. [1] Sobti *et al., Indian J. Pharm.*, 1958, **20,** 48; [2] Nazir & Handa, *J. sci. industr. Res.*, 1959, **18B,** 175; [3] Pillay *et al., Bull. Res. Inst., Univ. Kerala*, 1957, **5A** (1), 65.

TABLE 2—ALKALOIDS OF LOCHNERA ROSEA*

Alkaloid	Molecular formula	M.p.
Ajmalicine (δ-Yohimbine)	$C_{21}H_{24}O_3N_2$	250–52° (decomp.)
Akuammine	$C_{22}H_{26}O_3N_2$	254–59° (decomp.)
Catharanthine	$C_{21}H_{24}O_2N_2$	126–28°
Leurosine	$C_{46}H_{58}O_9N_4$	202–05° (decomp.)
Lochnericine	$C_{21}H_{24}O_3N_2$	190–93° (decomp.)
Lochnerine	$C_{20}H_{24}O_2N_2$	200–01°
Perivine	$C_{20}H_{22}O_3N_2$	180–81°
Reserpine	$C_{33}H_{40}O_9N_2$	284–85° (decomp., vac.)
Serpentine	$C_{21}H_{20}O_3N_2$	158°
Tetrahydroalstonine	$C_{21}H_{24}O_3N_2$	230–32°
Vincaleukoblastine	$C_{46}H_{58}O_9N_4$	211–16° (decomp.)
Vindoline	$C_{25}H_{32}O_6N_2$	154–55°
Vindolinine-2HCl	$C_{21}H_{24-26}O_2N_2.2HCl$	210–12° (decomp.)
Virosine	$C_{22}H_{28}O_4N_2$	258–64° (decomp.)

* Svoboda *et al.*, *J. Amer. pharm. Ass., sci. Edn*, 1959, **48**, 659; Manske & Holmes, VII, 64–66, 117, 123, 175.

albus, *Streptococcus haemolyticus*, *Cornybacterium diphtheriae* and a few other bacteria; leaf extracts form a useful anti-bacterial agent for the treatment of streptococcal and staphylococcal infections (Chopra *et al.*, *Indian J. med. Res.*, 1959, **47**, 39; Kamat *et al.*, ibid., 1958, **46**, 588).

Certain extracts of *L. rosea* are reported to produce limited prolongation of life in mice against experimental leukemia; the anti-leukemic activity resides in leurosine and vincaleukoblastine. *L. rosea* alkaloids also possess marked anti-diuretic action on rats (Svoboda *et al.*, loc. cit.; Neogi & Bhatia, *Indian J. Pharm.*, 1956, **18**, 73).

Neither the infusion of leaves nor of the whole plant produces any change in blood sugar level when administered orally to normal or alloxan-diabetic rabbits. It has been observed that certain diabetic patients using the drug find relief; in particular, the secondary symptoms of glycosuria, polyurea, excessive thirst and tiredness diminish or disappear in 2–3 weeks of continuous use. Clinical trials have shown that oral administration of infusion decreases glycosuria with rise in blood sugar, suggesting an increase in tubular reabsorption of glucose. However, in view of the presence of hypotensive alkaloids, the drug is not a safe remedy for diabetes except, perhaps, as an ingredient in suitable formulations [Mukerji, *J. sci. industr. Res.*, 1957, **16A**(10), suppl., 7; Pillay *et al.*, *Bull. Res. Inst., Univ. Kerala*, 1959, **6A**(1), 51].

The root bark contains a phenolic resin (2%), *d*-camphor (0.03%) and a neutral substance (m.p. 148°). The leaves yield an oleoresin and a small amount of volatile oil [sp. gr.$^{29°}$, 0.9705; $n_D^{29°}$, 1.4555; $[\alpha]_D^{30°}$, + 49.12°] containing aldehydes, sesquiterpenes and sulphur compounds; two alcohols, lochnerol ($C_{21}H_{36}O_3$. ½H_2O, m.p. 244–46°) and lochnerallol ($C_{26}H_{44}O_3$, m.p. 258°), two glycosides, tannin, carotenoids, sterols, ursolic acid and a flavone derivative are present. Rose-purple flowers contain an anthocyanin, probably hirsutidin diglycoside [Pillay *et al.*, *Bull. Res. Inst., Univ. Kerala*, 1957, **5A**(1), 65; *Chem. Abstr.*, 1938, **32**, 7514; Kamat *et al.*, loc. cit.; U.S.D., 1955, 1928; Ponniah & Seshadri, *J. sci. industr. Res.*, 1953, **12B**, 605].

Locust Bean — *see* **Ceratonia**

LOCUSTS (Order *Orthoptera*; family *Acrididae*)

D.E.P., IV, 470; VI(1), 154; C.P., 686; Uvarov, 1928.

SANS.—*Patanga, salabha*; HINDI—*Tiddi*; MAR.—*Tol, naktode*; TEL.—*Midatha, midatha dandu*; TAM.—*Vettukili*; KAN.—*Midchi, jitte*.

PUNJAB—*Makri, tiddi*.

Locusts are terrestrial insects with biting mouth parts, essentially vegetarian in food habits. They have a marked propensity for gregariousness and long migratory flights, and are destructive to crop and other economic plants.

About a dozen species of locusts have been recorded from different parts of the world. Of these three occur in India, namely, Desert Locust, Migratory Locust and Bombay Locust. Desert locust is the most destructive and is known to have been responsible for many a famine in the past.

DESERT LOCUST
(*Schistocerca gregaria* Forskal)

The desert locust is distributed from Rajasthan in the east to the Atlantic coast of Africa in the west; this region includes areas wherein it lives and breeds endemically. Swarming invasions of this locust in

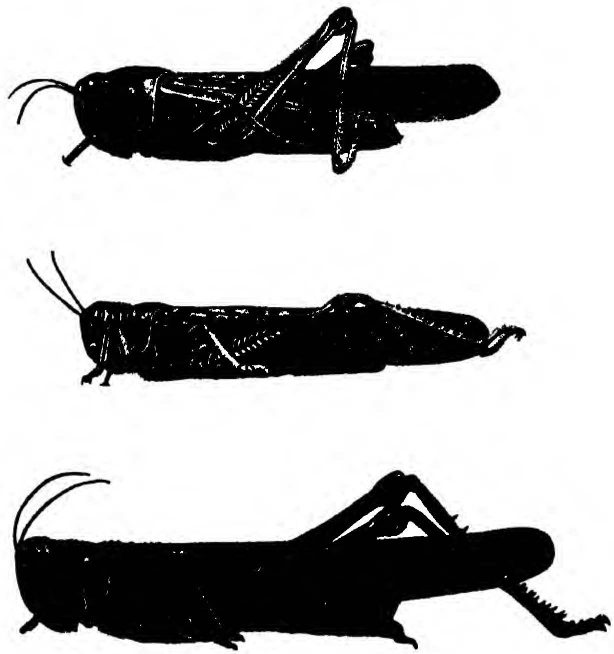


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FIG. 56. (1) MIGRATORY LOCUST — LOCUSTA MIGRATORIA (2) DESERT LOCUST — SCHISTOCERCA GREGARIA AND (3) BOMBAY LOCUST— PATANGA SUCCINCTA

India have extended as far east as Assam and as far south as Mysore.

In the endemic areas the desert locust can live and breed as solitary individuals (solitary phase) or a number of them in the immature hopper stages congregate into marching bands of hoppers which ultimately produce swarms capable of mass migratory flights over long distances (gregarious phase). Experimentally it has been possible to transform the locust from the solitary to the gregarious phase and *vice versa*.

Hoppers and adults of the two phases differ in colour. While hoppers of the solitary phase are more or less uniformly green throughout their life, simulating the colour of their vegetational environment, hoppers of the gregarious phase are mostly black in the first two of their five stages but subsequently develop vivid patterns of yellow, greenish yellow and red on their blackish bodies. Adults in the solitary phase remain grey throughout their life; in the gregarious phase, they are pinkish or reddish during the first 4 or 5 weeks or even longer, when they are sexually immature, after which the male adults usually turn yellow while females turn yellow or lead-grey.

Broadly speaking, there are two main breeding seasons and two categories of breeding areas, viz. winter-spring breeding in areas where the rainfall is confined mainly to winter and early spring and summer-monsoon breeding in areas where rainfall occurs largely during June–September. Coastal areas of the Red Sea, large parts of the Arabian peninsula, southern Iran, Baluchistan and southern Afghanistan are among the winter-spring breeding areas, while Sudan and some other territories in Africa, parts of West Pakistan, Rajasthan and parts of Bombay and Punjab States in India are among the summer-monsoon breeding areas. The swarms produced in the former areas migrate during spring and early summer to regions where rains occur in summer and monsoon months and lay eggs in June–September, sometimes even later. There is a return migration of swarms during autumn to areas of winter rainfall. This sequence of breeding and migration applies both to gregarious and solitary locusts: in the case of the latter, however, the migration is on a small scale and by isolated individuals.

Generally, two generations are produced in a year; sometimes there may be three or even more, specially in areas of summer-monsoon rainfall. Under experimental conditions, particularly when favourable temperature conditions are provided, the desert locust is continuously active irrespective of the stage of maturity or the season.

Reproduction—The time taken by the desert locust to attain sexual maturity is very variable. It may be 3–4 weeks during late spring and summer or several months during winter. Feeding on fresh, succulent vegetation, especially cereal crops like maize, *jowar* and *bajra* quickens sexual maturity. There may be 3–21 matings during the life span of the locust. Parthenogenetic development, leading to monosexual progeny of six successive generations of females has been observed under controlled laboratory conditions: this is, however, uncommon in nature.

Female locusts generally lay eggs by inserting the hind end of their body into moist, preferably sandy and loamy soil up to a depth of 10 cm. The eggs are deposited in clusters of 40–120 at the bottom of holes thus formed, the remaining space being filled up with a fluffy material which later hardens into a waterproof covering. The eggs resemble grains of rice, 4–8 mm. × 0.9–1.6 mm., yellowish in colour.

Eggs hatch in *c.* 12 days in summer and 21–28 days in autumn and spring; the period may be as long as 45 days in winter. All eggs in a cluster do not hatch simultaneously. Hatching extends over 3–5

days ; eggs last laid in a cluster hatch first. Hatching and emergence of hoppers in egg infested ground may continue for several days, sometimes as many as 10 days. Due to the water-proof plugging of egg holes, surface water does not usually affect hatching unless it is stagnant for 2–3 days at a stretch.

Hoppers—Hoppers emerging from eggs are dirty white or greenish white in colour. There are five stages in the growth of the hopper, at the end of each of which it casts off the skin in the manner of other insects whose immature (larval or nymphal) and adult stages are not markedly different from each other except in the matter of size, colouration and growth of wings. The newly hatched hopper is *c.* 6 mm. long and, in the gregarious phase, it resembles a large-sized black ant. It grows in size and develops wings in successive stages and in the fifth and last stage, the hopper is *c.* 39 mm. long and can jump a distance of over 60 cm. and to a height of *c.* 10 cm. During the summer, the hopper completes its development and emerges as an adult in 4–5 weeks ; it may take 6–8 weeks during autumn and spring, and even longer in winter.

The most dreaded habit of gregarious hoppers is the formation of bands and moving relentlessly in definite directions devouring all vegetation that may lie in their way. Such marches usually take place during the day and follow the direction of the wind. Hoppers in all stages, excepting the first, respond to movement but not to sound, and can be driven in any desired direction by suitable manipulation.

Adults—Flying locusts, emerging from the fifth or last stage hoppers, are sexually immature but are voracious feeders. Adults of the desert locust have a life span of 245 days under laboratory conditions at room temperature (in Punjab) ; under natural conditions the life period varies from 170 to 229 days. The body length of the adult male is 46–55 mm., that of the adult female *c.* 57 mm., with forewings in each case measuring a few mm. more. A dozen adult locusts weigh *c.* 28 g. Locusts are generally sluggish during mornings and evenings, during the day if the weather is cool and cloudy, and when mating.

Natural enemies—Locust eggs are attacked at times by some insects, notably forficulids. Hoppers and adults are subject to some fungal, bacterial and virus diseases. However, records of such cases in nature are not many ; there is hardly any record of locusts being parasitized by insects.

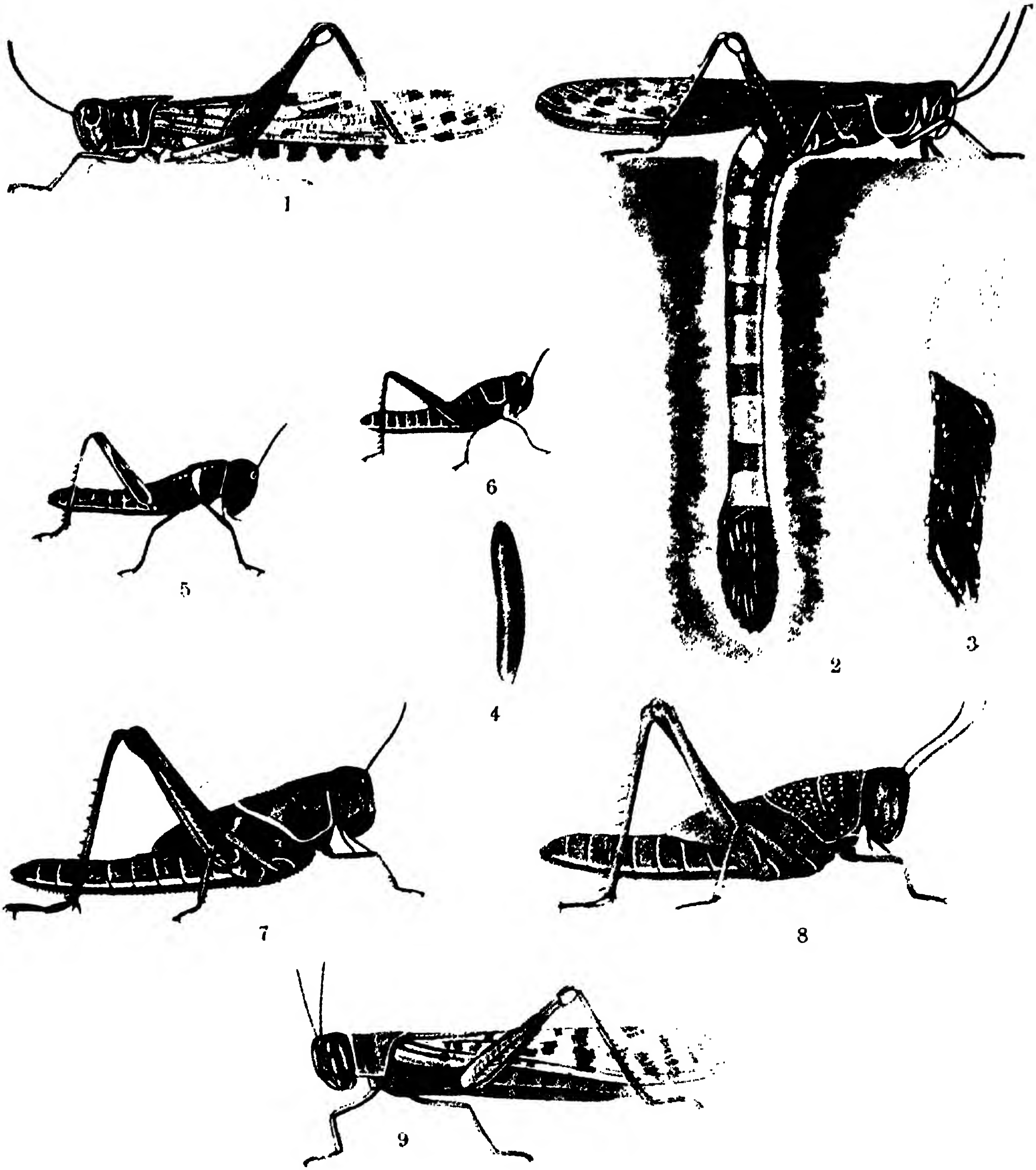
Birds constitute the most formidable enemies of locusts. They include the Indian crow (*Corvus splendens* Vieillot), rosy pastor (*Pastor roseus* Linn.), myna [*Acridotheres tristis* (Linn.)], grey partridge [*Francolinus pondicerianus* (Gmelin)], kite [*Milvus migrans* (Boddaert)], jungle babbler [*Turdoides somervillei* (Sykes)], shikra [*Astur badius* (Gmelin)], and others. Destruction by birds makes no impression on the population of locusts but birds provide useful clues to locust concentrations and thereby facilitate control operations.

Swarms—Swarms up to 207 sq. km. in spread have been observed in India ; there may be 40–80 million locusts per sq. km. Swarms generally fly by day and rest by night. Scattered locusts of the solitary phase are reported to fly only during nights, though flights have been observed on cool days.

Locusts generally fly with the wind so that they may eventually find themselves in zones of convergent wind flow, which is an essential factor for widespread heavy rain. This fact explains the association of swarms with the incidence and distribution of rainfall. The speed of travel depends on many factors of which the direction and velocity of prevailing wind are important ; cases are known of swarms having been carried over long distances more by winds than by their own efforts. There is a recorded case of a swarm having travelled for a few days in India at an average speed of about 21 km. per hour. Locusts can travel non-stop and without food over long distances.

Locust swarms are known to appear in cycles over a period of 3 to 9 years. This is true only with reference to specific regions because it has now been established that there is no period when the desert locust is not active in some part or the other within the region of its distribution. There are authentic records of locust invasions in India during 1863–67, 1869–73, 1876–81, 1889–98, 1900–07, 1912–20, 1926–31, 1940–46 and 1950–55.

Food—Locust hoppers and adults are general feeders, but certain exceptions to their catholic tastes have been observed. The desert locust in India does not feed on the leaves of *Melia azedarach* Linn., *Calotropis gigantea* R. Br. ex Ait. and possibly a few other plants. Leaves of onion, canna and *Azadirachta indica* A. Juss., formerly believed to be unacceptable to locusts, are eaten by them. The desert locust may feed, though not with relish, on agave, silk cotton tree, shoe flower, jasmine, water melon, chillies, *Aegle marmelos* Correa, *Datura stramonium* Linn. and *Buxus wallichiana* Baill. It feeds readily on bamboo, sugarcane, *jowar*, *bajra*, maize, smaller



DESERT LOCUST (SCHISTOCERCA GREGARIA) — LIFE CYCLE

1. Adult solitary female 2. Egg laying 3. Egg cluster 4. Egg 5,7. Hoppers—gregarious phase 6,8. Hoppers solitary phase 9. Adult—gregarious phase

millets, wheat, barley, paddy, gram, *arhar, urd*, soyabean, castor, mustard, linseed, groundnut, sann-hemp, cotton, jute, turmeric, tobacco, potato, lady's finger, *Colocasia esculenta* Schott, tomato, turnip, cabbage, cauliflower, spinach, white gourd, sweet melon, brinjal, globe artichoke, mango, apple, peach, pear, loquat, guava, fig, pomegranate, papaya, Cape gooseberry, sweet lime, orange, banana, mulberry, lantana, *Boehmeria nivea* Gaudich., eucalyptus, rose, tamarind, teak, *Acacia arabica* Willd., *Dalbergia sissoo* Roxb., *Syzygium cumini* (linn.) Skeels, *Prosopis juliflora* DC., etc. The list is not exhaustive. In general, soft and succulent leaves are eaten with avidity.

Control measures—The control of the desert locust involves the prevention of swarm formation. As the breeding and swarm formation in one country may have serious repercussions in other, and even widely separated countries, the problem has to be tackled on an international basis. Since 1953, the Food and Agriculture Organization of the United Nations has been organizing annual campaigns against the desert locust in the Arabian Peninsula.

The measures employed in the past for fighting locust plagues include: beating drums, empty tins, etc.; burying locust hoppers in specially prepared linear trenches; digging and destroying eggs; and ploughing or flooding of egg-infested grounds. During the locust plague of 1926–31 in India, a poison bait containing sodium fluosilicate was employed. In recent years poison baits containing benzene hexachloride have come into use. They are effective in dry areas but have severe limitations. Baiting has now been discarded in favour of dusting and spraying with synthetic insecticides.

Dusting with 5–10% benzene hexachloride is effective against hoppers and adults; even lower concentrations (1.5–3%) are effective against hoppers in the first and second stages. Other insecticides that have proved effective as dusts or sprays, or both, against various stages are: Lindane, Acrodel and Heptachlor, Aldrin and Dieldrin, Malathion and Folidol, and DNC. Although DDT can kill locusts, it has not been found economical.

Much work has been done on techniques of insecticide application. Spraying of ground strips, a few metres in width, across the path of advancing hoppers so that they may imbibe the poison and get killed, has led to economy of insecticides, labour and time. Spraying of egg-infested grounds with insecticides which have a fairly long residual effect, e.g. Aldrin, so that emerging hoppers may come into contact with the poisoned surface, has proved effective. The residual effect of Aldrin lasts for two weeks or more. In view of the scarcity of water in desert areas, low volume spraying machines have been employed which cut down the quantity of liquid spray required per acre from 30–40 gallons to only a few gallons. The most notable development has been the use of aircraft for spraying egg-infested grounds, hopper concentrations and locust swarms while resting or in flight.

Locust control in India—The responsibility for locust control in the desert areas, lying mostly in Rajasthan and covering a total area of *c.* 2,12,400 sq. km., is that of the Government of India. Locust control in cultivated areas is the responsibility of concerned State governments. The Government of India's agency for locust control is the Directorate of Plant Protection, Quarantine and Storage. The Directorate has a Locust Warning Organization, created in 1939, which carries out locust surveys and sometimes also undertakes control measures against incipient or scattered breeding and hoppers even during periods when locusts are not active. During plague periods the Locust Warning Organization serves the needs of intelligence and control. A co-ordinated anti-locust scheme is brought into operation under which governments of States which are vulnerable to locust attacks contribute to the expenditure on locust control in the scheduled desert area according to an agreed formula.

Economic losses due to locust plagues—The value of crops lost during the locust plague of 1926–31 in India, has been estimated at Rs. 10 crores. The loss during the more recent plague of 1950–55 was *c.* Rs. 2.07 crores. Since the prices of agricultural commodities during the latter period were approximately four times those prevailing during 1926–31, the value of the loss during 1950–55 may be reckoned at Rs. 52 lakhs for purposes of comparison. This reduction in loss during 1950–55 is attributed to improvements in the techniques, organization and facilities for locust control.

Uses—Locusts are used as food by some section of the population in several countries, including India; they may be eaten in the fresh or the dried state; they may also be preserved in salt. They are rich in protein and fat and are reported to have good nutritive value. Analysis of air-dried adult desert locusts gave the following values: moisture, 5.03; ether extr., 16.95; crude protein, 61.75; sol.

carbohydrates, nil; fibre, 10.00; and silica, 1.63%. Locusts may be used as manure; they contain: nitrogen, 9.90; phosphate (P_2O_5), 1.20; potash (K_2O), 0.84; and lime (CaO), 0.59%. Nitrogen is present largely in the form of chitin which decomposes slowly in the soil. The use of locust meal as a substitute for oil cakes in animal feeding has been suggested (Husain & Ahmad, *Indian J. agric. Sci.*, 1936, **6,** 188; Husain & Mathur, ibid., 1936, **6,** 591; Rao, *Proc. Indian Sci. Congr.*, 1943, 201; Report of the FAO Panel of Experts on long-term policy of desert locust control, 1956; Das, *Indian Fmg*, 1945, **6,** 412; *Chem. Abstr.*, 1934, **28,** 7378).

Migratory Locust
(*Locusta migratoria* Linn.)

The migratory locust is widely distributed in the Old World. Its occurrence, however, is localized in certain regions; it is not found in the colder regions beyond the sixtieth parallel North and South, in dense tropical forests and in waterless deserts. This species is a serious pest in southern Russia, Nigeria, Madagascar, and some areas in Africa and Philippines. As solitary individuals, the migratory locust is known to occur practically all over India, notably in the States of Rajasthan, Bombay and Madras.

The migratory locust may occur as solitary individuals or in swarms. The former are referred to as *L. migratoria danica* Linn. and the latter as *L. migratoria migratoria* Linn. in northern areas and conditions and as *L. migratoria migratorioides* Reich. & Frem. in tropical areas and conditions. In the solitary form, this species is known to occur even at very high altitudes; in the Himalayas, it is found up to an altitude of 4,600 m. The areas from where swarms arise are associated with swampy conditions and growth of reeds, bamboos and other tall plants.

Very little is known of this locust in India. The earliest record of its invasion was in 1878 in Madras, from where the swarms spread as far as Bombay. There was another swarm over Bangalore district in June 1954. Concentrated breeding was reported in parts of Bombay and Rajasthan during 1937, when hoppers caused appreciable damage to crops, and again during 1956 in some areas in Rajasthan, but most of the hoppers were destroyed.

The solitary phase adult is often green, sometimes blackish. The gregarious phase adult is greyish green or yellowish; sexually mature males are bright yellow while the females are reddish brown. Hoppers of the solitary phase are usually green, sometimes grey or black but without any definite pattern. Hoppers of the gregarious phase are generally black, but brown predominates in the third stage; the colour is pale in the fourth stage and brown with reddish tinge in the fifth stage. Male and female adults of the gregarious phase are respectively 40-50 mm. and 42–55 mm. long and those of the solitary phase 29–35 mm. and 37-60 mm. long with forewings a little longer in each case.

Sexual maturation of adults and egg-laying are quicker in solitary than in gregarious locusts. Breeding is conditioned largely by high humidity, brought about by local rainfall or presence of large sheets of water. Eggs are laid in pods, preferably in moist and clayey soil. Under laboratory conditions, the total number of egg pods laid by a female may be seven or so, each pod containing 49–104 eggs, and the total number of eggs laid by a female may be c. 500 in the case of the solitary locust and 330 in the case of the gregarious locust. Eggs remain viable even after several months' submersion under water. There is evidence of overwintering in the adult locust and spring breeding was observed in India in 1956-57. There may be two generations of the locust in a year in India; a maximum of three generations is considered possible in Nigeria. Under optimum laboratory conditions, breeding continues all the year round and five or six generations may be possible.

Flying swarms may cover a distance of 60 km. or so; swarms in 1878 and 1954 in India covered much longer distances. There is a strong probability of solitary locusts migrating individually from one area to another. The migrations of swarms are often upstream and from one breeding ground to another.

The migratory locust is much more restricted in the choice of food plants than the desert locust. In certain Russian and Central Asian regions, reeds form the staple food. Most grasses are eaten, including species of *Cynodon, Vetiveria, Sorghum, Pennisetum, Echinochloa* and *Brachiaria.* This locust has been successfully reared in the laboratory on fresh grasses of *Poa* spp. and on dry hay sprinkled with water. During the 1954 infestation in India, hoppers attacked mostly grasses and sedges (*Cyperus* spp.), though cereals and paddy were also eaten at places. Cotton and groundnut were not touched; cabbage and lucerne are eaten very reluctantly or after a period of starvation. During the 1937 infestation, *bajra* and *jowar* crops were damaged in Bombay State.

Several birds, notably bustards, cattle egret (*Bubulcus ibis* Linn.), bee-eater (*Merops orientalis*

Latham), kites and storks, attack and eat hoppers and adults during rest or flight.

The migratory locust contains 8% fat composed of the following acids: myristic, 1.0; palmitic, 24.5; stearic, 7.3; hexadecenoic, 2.1; oleic, 12.4; linoleic, 35.1; linolenic, 17.3; and unsaturated C_{20}, 0.3% (Rao & Bhatia, *Indian J. agric. Sci.*, 1939, **9**, 79; Norris, *Anti-Locust Bull.*, No. 6, 1950; Davey & Johnston, ibid., No. 22, 1956; Hilditch, 1956, 75).

BOMBAY LOCUST
(*Patanga succincta* Linn.)

The Bombay locust, distributed in the Indo-Ceylon region, China and South-East Asia, is a potential and sporadic pest causing damage to crops. In its solitary phase, the locust is found throughout the greater part of India, except in Assam, Punjab and Kashmir. Swarms have been occasionally observed in various parts of the country: there has been no report of any swarm since 1927. Its main areas of breeding lie in forest regions of western ghats: breeding may also occur in parts of Central India, eastern ghats and Rajasthan.

The colour of the solitary adult is brown or pale brown: that of the adult in a swarm is red or reddish. During the period of oviposition, the colour may be dark brown. The general colouration of the hopper is green with minute black dots which become more and more distinct as the hopper advances in age; in the very advanced stage, the hopper acquires a brownish tinge over its green body. Gregarious hoppers of the Bombay locust are not known. The body length of the adult male is 48–56 mm. and that of the adult female, 57–63 mm.; with the forewings the lengths of both are slightly longer.

The adult of the Bombay locust takes about ten months (September–June) to attain sexual maturity. Eggs are laid in moist, clayey soil, sparsely covered with grasses or cultivated vegetation. Perhaps only one egg mass is laid by the female in its life time, and eggs hatch in 6–8 weeks. In their development, the hoppers pass through 7 or 8, rarely 9, stages in 8–10 weeks before they become adults. A high degree of atmospheric humidity is essential for development and failure of rains when hoppers are developing results in the death of a large number of them. The adults of the generation produced in September may form swarms and fly in the direction of the prevailing wind. They are relatively inactive during the cold weather and flights are resumed again in spring and summer. There is only one generation of Bombay locust in a year.

Like the migratory locust, the Bombay locust also prefers grasses to other plants for food. Various millets, like *bajra*, *jowar* and ragi, mango, citrus, coconut palm and various forest trees have been recorded as food plants.

Lodestone — *see* **Iron Ores**

Lodh Tree — *see* **Symplocos**

LODOICEA Comm. (*Palmae*)

A monotypic genus represented by *L. maldivica*, a palm native of Seychelles Islands. It is grown in Indian gardens for ornament.

L. maldivica (Poir.) Pers. syn. *L. seychellarum* Labill. DOUBLE COCONUT PALM, SEA COCONUT PALM

D.E.P., V, 87; Blatter, 213, Pl. XL–XLV, Fig. 29.

HINDI—*Darya-ka-naryal*; MAR.—*Jahari-naral*; GUJ.—*Daryanunariyal*; TEL.—*Samudrapu tenkaya*; TAM.—*Kadalthengai;* MAL.—*Kataltenna, akraritennu*.

A tall, dioecious palm, with straight, smooth, annulated trunk, 18–30 m. high and 0.3 m. diam. It bears a crown of 12–20 large, fan-shaped leaves with stout petioles; fruits large, up to 1.2 m. in circumference and 11.4 kg. in weight (max. recorded wt., 27.2 kg.), olive-green, usually one-seeded; nut (pyrene) large, deeply bilobed, bony, firmly attached to

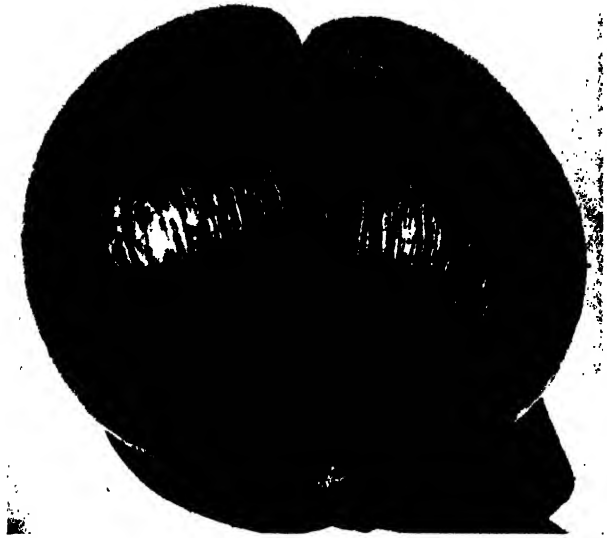


Photo: D. Chatterjee, Calcutta

FIG. 57. LODOICEA MALDIVICA—DOUBLE COCONUT

mesocarp ; shell thick, black. The nuts are reported to be imported into India.

L. maldivica is a giant among palms. It can grow on all types of soils from the sandy shore to the arid mountain top, but thrives best in deep gorges covered with plant debris. For successful culture, thorough drainage, abundance of moisture and a hot climate are necessary. The nut takes about 2–3 years for germination. The palm flowers when 30 years old and takes about 3 to 10 years from the time of flowering to the maturation of fruits (Blatter, 222–24, 230 ; Bailey, 1947, II, 1900).

The nut is used for making plates, dishes and drinking cups ; it is carved into ornaments. The hard kernel (endosperm) affords vegetable ivory. The unripe kernel and the crown of the trunk are edible. The water of the green fruit and its soft kernel are considered antibilious and antacid. A decoction of the fibrous husk is reported to bring down urinary sugar level in diabetic patients, but the effect is temporary (Blatter, 243 ; Burkill, II, 1363 ; Kirt. & Basu, IV, 2577 ; Koman, 1919, 17).

The leaves of the palm are used for thatching and for making baskets. Unexpanded, tender leaves are dried in the sun, cut into longitudinal strips and plaited into hats. Brooms and baskets are made from the ribs of leaves and petioles. The woody trunk is used as water troughs, palisades for houses and walking sticks. The down attached to young leaves is suitable for stuffing pillows and mattresses (Blatter, 243 ; Williams & Williams, 209).

Logan — *see* **Euphoria**

Logwood — *see* **Haematoxylon**

LOLIUM Linn. (*Gramineae*)

A small genus of erect, annual or perennial grasses distributed in temperate Asia, Europe and North Africa. About 4 species have been recorded in India.

L. multiflorum Lam. syn. *L. italicum* A. Br. Italian Ryegrass

Fl. Assam, V, 66 ; Hubbard, 131, Fig. p. 130.

An annual or biennial grass with tufted stems, 20–100 cm. high, found in temperate parts of the Old World. It has been introduced into Shillong (Assam) along with other grass seeds from southern Europe.

L. multiflorum is a valuable fodder grass for grazing, as also for use as hay. It thrives well on moist fertile soils, especially those irrigated with sewage effluent and produces a great bulk of herbage. It is a short duration grazing plant which recovers rapidly after defoliation. It is relished by livestock and makes a good nurse crop for permanent pastures. It also makes a fine temporary lawn. It has been crossed with *L. perenne* and a short duration ryegrass highly palatable has been obtained (Robinson, 1949, 260 ; Schoth & Hein, *Leafl. U. S. Dep. Agric.*, No. 196, 1948 ; Hall, 164).

The composition of Italian ryegrass and its seed is given in Table 1. The grass is a good source of carotene (609 μg./g., dry basis) and vitamins of the B group (riboflavin, 27.5 ; pantothenic acid, 19.5 ; nicotinic acid, 54.2 ; and thiamine, 13.3 μg./g., dry basis). An alkaloid, perloline, is present. The seeds provide a feedstuff rich in carbohydrates. They contain a gluten similar to wheat gluten (Moyer *et al.*, *Agron. J.*, 1949, **41,** 344 ; Henry, 750 ; Common, *J. agric. Sci.*, 1945, **35,** 56 ; *Chem. Abstr.*, 1933, **27,** 3756).

L. perenne Linn. Perennial Ryegrass

D.E.P., V, 88 ; Fl. Br. Ind., VII, 365 ; Hubbard, 129, Fig. p. 128.

A perennial grass with tufted stems, up to 90 cm. high, found in western Tibet at *c.* 4,500 m. Leaves flat, hairless, pointed or blunt, up to 30 cm. long and 1.25 cm. broad ; spikes straight with spikelets stalkless ; grain glabrous tightly enclosed in the hardened lemma and palea.

The grass has been introduced into Simla, Sikkim (2,100 m.), Shillong, Nilgiri and Palni hills. It is considered worthy of trial in the lower foothills, valleys and highlands of S. India and also in such places as Kangra valley in Punjab, where grazing is deficient. It responds well to cultivation and manuring, and can be grown in mixture with clover and other grass species. It withstands cutting and grazing, and yields an excellent fodder for horses, cattle and sheep (Lander, 153 ; Bell, 45 ; Robinson, 1949, 259 ; Davies, 121 ; Hall, 155 ; Schoth & Hein, loc. cit.).

Perennial ryegrass is valuable as pasture, ley or sward. For making hay, the grass is cut when the seed is in the soft dough stage. Table 1 gives the chemical composition of grass, hay and seeds. The grass is a good source of carotene (4.8 mg./100 g.). It contains free fructose, fructosan, mannitol, and a complex mixture of oligosaccharides : oxalic, citric, malic and shikimic acids are present and a few amino acids have been identified. The grass also contains glycerides and a wax containing hexacosanol (Schoth & Hein, loc. cit. ; Morrison, 378, 1106 ; *Nutr. Abstr.*

TABLE 1—CHEMICAL COMPOSITION OF RYEGRASSES AND THEIR SEEDS

	Dry matter %	Protein %	Fat %	Fibre %	N-free extr. %	Mineral matter %	Digestible protein %	Total digestible nutrients %	Nutritive ratio
L. multiflorum (Italian ryegrass)									
Green grass*	27.1	3.1	1.3	6.8	13.4	2.5 (Ca, 0.13; P, 0.08; K, 0.40%)	1.9	18.3	8.6
Hay*	88.6	8.1	1.9	27.8	43.3	7.5	3.4	52.3	14.4
Seed†	.	9.8	2.4	10.3	71.8	5.7	..	..	..
L. perenne (Perennial ryegrass)									
Green grass*	26.6	3.0	1.3	6.7	13.2	2.4 (Ca, 0.12; P, 0.07; K, 0.51%)	1.9	18.0	8.5
Hay*	88.0	9.2	3.1	24.2	43.4	8.1	4.7	52.5	10.2
Seed†	87.0	9.2	2.1	8.9	62.4	4.2	5.3	59.5	..
L. temulentum (Darnel)									
Green grass††	..	3.6-10.9	1.5-2.6	26.9-39.0	40.4-56.2	7.1-11.9	..	..	..

* Morrison, 1032, 1014; †Common, *J. agric. Sci.*, 1945, **35**, 56; ††Chopra *et al.*, *Indian J. agric. Sci.*, 1956, **26**, 415.

Rev., 1947-48, **17**, 619; Wylam, *J. Sci. Fd Agric.*, 1954, **5**, 167; Harwood, ibid., 1954, **5**, 453; Richardson & Hulme, *Nature, Lond.*, 1955, **175**, 43; Armstrong, *J. Sci. Fd Agric.*, 1951, **2**, 166; Synge, *Biochem. J.*, 1951, **49**, 642; Warth, 233).

Three alkaloids have been separated from the grass; they are: perloline ($C_{10}H_{31}O_7N_1$, m.p. 181°), perlolidine ($C_{25}H_{18}O_2N_1$, m.p. 325-26°) and a liquid base C_6H_7N (m.p. of picrate 154–56°). Perloline forms the major component; it is fluorescent and is mildly toxic to mice; there is evidence to suspect that it causes facial eczema in livestock feeding on the grass (Henry, 749; *Chem. Abstr.*, 1944, **38**, 1073).

As a feed for livestock, the seeds of *L. perenne* are comparable to oats in nutritive value. They contain a prolamine and a gluten similar to wheat gluten (Common, *J. agric. Sci.*, 1945, **35**, 56; Wehmer, II, 1296; *Chem. Abstr.*, 1933, **27**, 3756).

Though an excellent fodder and pasture grass, exclusive feeding on *L. perenne* is reported to cause diseases in animals, probably due to the grass being ergotized or otherwise affected.

L. temulentum Linn. DARNEL

D.E.P., V, 90; Fl. Br. Ind., VII, 364; Hubbard, 133, Fig. p. 132.

HINDI—*Mochni.*

PUNJAB—*Mostaki.*

An annual grass with a stout and erect stem, 30-90 cm. high, found as a weed of cultivation in the upper Gangetic plain, Punjab and western Himalayas up to 1,800 m.; it occurs in Shillong as an escape. Leaves glabrous, 15-30 cm. long, 3-8 mm. broad; spikes erect, 8–30 cm. long with 10–20 spikelets; grain elliptic oblong, semiterete, grooved in front. The plant is a native of temperate Asia, southern Europe and North Africa and has spread to many other countries (Fl. Assam, V, 66).

The grass affords a nutritive feed for livestock, but animals should not be allowed to graze after the setting of seeds. The chemical composition of grass from Kashmir is given in Table 1. It contains the alkaloid, perloline (Chopra *et al.*, *Indian J. agric. Sci.*, 1956, **26**, 415; Chopra *et al.*, 70; Henry, 750).

The seeds have a composition similar to that of oats and are innocuous to livestock when free from fungus infection. The seeds are liable to infection by ergot, mildew and other fungi, particularly *Endoconidium temulentum* Pritt & Deloer. Infected seeds are poisonous and cause gastro-intestinal irritation, convulsions, paralysis and severe nervous symptoms. Several cases of poisoning in man and livestock due to admixture of wheat or other cereals with infected darnel seeds have been reported. The toxic principle is considered to be a liquid narcotic alkaloid, temuline ($C_7H_{12}ON_2$), produced by the fungus *E. temulentum*;

loliine, which is also reported to be present, produces similar effects (Winton & Winton, I, 185; U.S.D., 1955, 1744; Fl. Egypt, I, 308; Greval & Bhaduri, *Indian med. Gaz.*, 1946, **81,** 294; Watt & Breyer-Brandwijk, 5).

Longan—*see* **Euphoria**

LONICERA Linn. (*Caprifoliaceae*)

A genus of erect, climbing or scrambling shrubs distributed chiefly in the sub-tropical and temperate regions of the northern hemisphere. About 40 species are found in India; a few exotics are cultivated for ornament.

Popularly known as Honeysuckles, some species of *Lonicera* are highly valued in gardens for their handsome foliage and fragrant flowers. They thrive well in hill stations; climbers are particularly well suited for covering arbours, railings and trellises; bushy species bear attractive berries varying in colour from white, yellow, purple or blue to black. Honeysuckles are easy to grow and may be propagated by seeds, cuttings or layering (Bor & Raizada, 156–60; Burns & Davis, 58, 106; Chittenden, III, 1202; Gopalaswamiengar, 358).

L. japonica Thunb. JAPANESE HONEYSUCKLE

Bor & Raizada, 159, Pl. 57, Fig. 101.

LUSHAI—*Leihruisen.*

A large climber found in Lushai hills (Assam) at an altitude of 750 m. and commonly cultivated in gardens. Leaves ovate to oblong-ovate, glabrous or sparsely hairy; flowers in axillary pedunculate pairs, often crowded at the ends of branches, fragrant, white or purple-tinged, changing to yellow; berries black [Fischer, *Rec. bot. Surv. India*, 1935, **12**(2), 100].

L. japonica is commonly met with in gardens both in the plains and on the hills. It thrives best on good loams but does well on any fair garden soil. It is somewhat susceptible to frost. It forms a good ground cover and soil binder. If allowed to grow unchecked, it may become a noxious weed covering pastures or smothering young tree growth in woodlands, and requiring the use of weedicides, e.g. 2,4-D, ammonium sulphamate or monothiophenolic compounds, for checking its spread (Macself, 128; Beale, *J.N.Y. bot. Gdn*, 1950, **51,** 68; *Chem. Abstr.*, 1949, **43,** 1895; 1944, **38,** 2159; 1952, **46,** 1213).

Japanese honeysuckle is browsed by cattle, especially when other roughage is in short supply; wild animals and birds have been observed to feed on it in winter. In U.S.A., it is considered to have some possibilities as an emergency green roughage for dairy cattle. In nutritive value, it is comparable to common forage grasses (Noland & Morrison, *J. Dairy Sci.*, 1954, **37,** 173).

The plant has long been used in China as an antipyretic, stomachic and in dysentery; dried flowers are considered diuretic. The plant contains tannin and a saponin; luteolin and *i*-inositol have been isolated from the flowers. The berries are rich in carotenoids, of which cryptoxanthin is the major component (*Chem. Abstr.*, 1942, **36,** 1731; 1950, **44,** 1977; Quisumbing, 929; Goodwin, *Biochem. J.*, 1952, **51,** 458).

L. periclymenum Linn. WOODBINE HONEYSUCKLE

D.E.P., V, 90; Bailey, 1949, 941.

A small climbing shrub cultivated in hill stations in India for its sweet-scented flowers. Leaves ovate or elliptic to ovate-oblong, sometimes slightly pubescent; flowers in terminal heads, fragrant, yellowish white, often purplish outside; berries globose, red.

L. periclymenum is a shrub eaten by cattle, in the green as well as dry condition. The flowers have a delightfully sweet fragrance, but have not been utilized for the extraction of perfume on a commercial scale. Honeysuckle perfumes of commerce are synthetic products. The flowers contain a colouring matter which dyes aluminium mordanted cotton pale dull yellow. They also contain a mucilage and possess anti-spasmodic, diuretic and sudorific properties; they are used in the form of syrup in diseases of the respiratory tract and spleen. The leaves contain an amorphous glycoside and salicylic acid (*Jt Publ. imp. agric. Bur.*, No. 10, 1947, 224–25; Poucher, II, 131–32; Perkin & Everest, 636; Steinmetz, II, 282; Wehmer, II, 1188).

L. quinquelocularis Hardw. HIMALAYAN HONEYSUCKLE

D.E.P., V, 91; Fl. Br. Ind., III, 14.

KASHMIR—*Tata bateri, pakhur;* PUNJAB HILLS—*Bakru, phut;* KUMAON & U.P. HILLS—*Taknoi, bhati, badkukra, badru.*

A large deciduous shrub, rarely a small tree, found in the Himalayas from Kashmir to Bhutan up to an altitude of 4,000 m. Bark pale brown or whitish, rather rough with shallow longitudinal cracks, peeling off in fibrous strips; young shoots densely pubescent; leaves ovate or broadly lanceolate, more or less pubescent; flowers in axillary pairs, white fading to yellow; berries ovoid, whitish. The plant is susceptible to attack by cantharid beetle, *Cantharis* (*Epicauta*) *antennalis* Mais., and the fungus, *Fomes*

conchatus (Pers.) Fr. (Stebbing, 248 : Khan, *Pakist. J. Sci.*, 1952, **4**, 65).

The sapwood is white ; heartwood greyish brown, very hard, heavy (wt., 52 lb./cu.ft.) and close-grained. It is suitable for turnery, carving, tool handles and ploughs. The branches are sometimes used as walking sticks. The outer bark yields a fibre suitable for stuffing mattresses. Leaves are used as fodder for goats (Gamble, 397–98 ; Gupta, 265 ; Laurie, *Indian For. Leafl.*, No. 82, 1945, 3).

L. angustifolia Wall. ex DC. (Punjab—*Mithiga, jinjru, philku* ; U.P.—*Geang, chalu, pirlu, banchulu*) is a shrub 1.8–3.6 m. high, with sweet, edible berries, found in the Himalayas from Kashmir to Sikkim at altitudes of 1,800–3,600 m. The cantharid beetle, *Cantharis* (*Epicauta*) *antennalis* Mais., attacks this species. The wood (wt., 60 lb./cu.ft.) is white, hard and close-grained. Branches are used for walking sticks (Gupta, 264 : Stebbing, 248 ; Gamble, 397).

L. glauca Hook. f. & Thoms. (Punjab & Kumaon—*Shintik, shewa, shea*) is a small erect or decumbent shrub found in the Himalayas from Kashmir to Kumaon at altitudes of 3,600–4,800 m. The seeds are reported to be given to horses for colic.

L. hypoleuca Decne. (Punjab Hills—*Kharmo, kodi, zhiko, rapesho*) is a spreading shrub found in the arid tracts of the Himalayas from Kashmir to Kumaon, at altitudes of 2,100–3,000 m. The leaves are eaten by camels, goats and sheep. The wood is white, moderately hard and close-grained (Gamble, 398).

L. rupicola Hook. f. & Thoms. is a rigid shrub found in the inner dry ranges of the Himalayas north of Kumaon and Sikkim at altitudes of 3,600–4,200 m. It is reported to form good hedges between the fields.

L. tomentella Hook. f. & Thoms. is a shrub found in Sikkim at altitudes of 2,400–3,600 m. It is reported to contain saponin (Wehmer, II, 1188).

L. webbiana Wall. syn. *L. alpigena* C. B. Clarke (Fl. Br. Ind.), non Linn. (U.P.—*Phulor*) is a medium-sized to large shrub found in the Himalayas from Kashmir to Kumaon at altitudes of 2,100–3,900 m. The wood is white, moderately hard and used as fuel (Gamble, 398).

LOPHATHERUM Brongn. (*Gramineae*)

Fl. Br. Ind., VII, 331.

A small genus of tall, slender grasses distributed in South-East Asia and North-East Australia. One species, *L. gracile* Brongn., a loosely tufted perennial grass with fleshy roots and broad, flat leaves, is found in tropical Himalayas from Sikkim eastwards and in the plains and hills of Assam up to 1,200 m. ; it is also reported to occur in Travancore. It puts forth an abundance of foliage, eaten by all animals. Vegetative parts are considered carminative, stomachic, antifebrile and diuretic in China (Fl. Assam, V, 60 ; Fl. Madras, 1847 ; Burkill, II, 1364 ; Cains, *J. Bombay nat. Hist. Soc.*, 1935–36, **38**, 565).

LOPHOPETALUM Wight (*Celastraceae*)

A genus of trees and shrubs distributed from India to New Guinea. Three species are found in India.

L. fimbriatum Wight

Fl. Br. Ind., I, 615.

Assam—*Rumu*.

A medium-sized to large deciduous tree, 18–30 m. in height (bole, 12–15 m.) and 2.4–4.5 m. in girth, found in the lower hill forests of Bengal and in Assam. Bark grey, rough with horizontal wrinkles, pink inside ; leaves ovate or ovate-oblong, subcoriaceous ; flowers in lax cymes, yellow or red.

The wood is pale yellow to light pink or brownish grey, somewhat lustrous, straight-grained, medium- and even-textured, moderately hard, strong and light (sp. gr., 0.53 ; wt., 34 lb./cu.ft.). It seasons without difficulty, but is liable to develop radial splits ; green conversion and proper stacking are recommended. In Assam, logs generally lie in the forest for six months after felling and floating in streams for a further period of six months ; the material obtained by extraction and conversion is quite sound (Pearson & Brown, I, 279–80).

The wood is durable under cover but not in the open or in contact with ground. It works well with tools and on the lathe giving a fine smooth surface. It is much used for boxes, especially tea chests ; it is suitable for general carpentry purposes and aeroplane frames (Pearson & Brown, I, 280 ; Fl. Assam, I, 267).

L. wightianum Arn.

D.E.P., V, 92 ; Fl. Br. Ind., I, 615 ; Talbot, I, 273, Fig. 161.

Tam.—*Venkottei, vengalkattei* ; Kan.—*Banate, balpale, bilihalasu, sattale, hottale* ; Mal.—*Venkotta, venkadavan*.

Coorg—*Palmani*.

Trade—*Banati, balpale*.

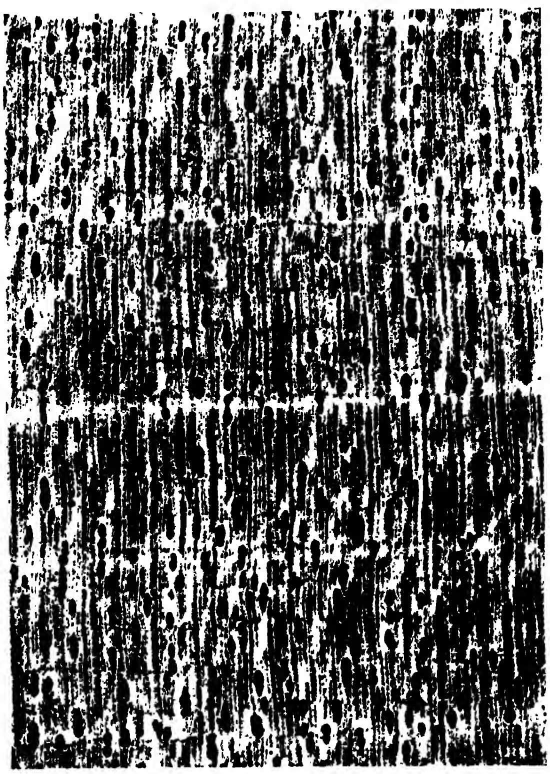
A large evergreen tree, sometimes up to 30 m. in height (bole, 15–18 m.) and 3 m. in girth, found on the west coast from Konkan southwards up to an

altitude of 900 m.; it is common in the evergreen forests of Travancore and on river banks at low elevations. Bark greyish brown, scaly, blaze flesh-coloured; leaves ovate-oblong or oblong-lanceolate, coriaceous; flowers in paniculate cymes, dull reddish or purple; capsule *c.* 12.5 cm. × 5.0 cm.; seeds thin, broadly winged.

Natural reproduction of the tree is generally adequate. It may be artificially propagated by transplanting seedlings under overhead shade; the plant is a shade-bearer. The rate of growth is usually fast (*Indian For.*, 1952, **78,** 348; Troup, I, 210).

The wood is pale yellow to light pinkish or brownish grey, somewhat lustrous, straight-grained, medium- and even-textured, moderately hard and light (sp. gr., 0.43; wt., 28 lb./cu.ft.). It air-seasons well and develops only a few fine cracks. It can be kiln-seasoned in 4–5 days; initial steaming for 2 hours at 55°/100% R.H. is necessary to sterilize the wood (Pearson & Brown, I, 277–78; Rehman, *Indian For.*, 1953, **79,** 369).

The wood is fairly durable under cover; graveyard tests gave an average natural durability of 2–5 years.



F.R.I., Dehra Dun. Photo: S. S. Ghosh

FIG. 58. LOPHOPETALUM WIGHTIANUM—TRANSVERSE SECTION OF WOOD

The wood is reported to last longer if smoked. It is liable to insect and fungal attack; powellizing or treatment with salt solution are recommended as protection measures. It is easy to saw and work and finishes to a smooth surface which takes a good polish. The data for the comparative suitability of banati timber, expressed as percentages of the same properties of teak, are: wt., 65; strength as a beam 50; stiffness as a beam, 60; suitability as a post, 55 shock-resisting ability, 50; retention of shape, 80 shear, 65; and hardness, 45 (Pearson & Brown, I 278; Purushotham *et al.*, *Indian For.*, 1953, **79,** 49; Sekhar & Bhatnagar, ibid., 1955, **81,** 420; Bourdillon, 89; Limaye, *Indian For. Rec., N. S., Timb. Mech.*, 1954, **1,** 53, Sheet No. 12).

Banati is a popular light timber much used for building purposes. It is suitable for furniture, cabinet work, panels for railway carriages, plywood and veneers, tea chests, light and heavy packing cases, coffins, bobbins, match boxes and splints; timber with wavy figuring is used for ornamental work. The wood can be rendered suitable for pencil making by proper treatment (Pearson & Brown, I, 278–79; Howard, 311; *Indian For.*, 1952, **78,** 274; IS: 399, 1952, 25, 28, 35; Trotter, 1944, 198; Krishnamurti Naidu, 84; Rehman & Jai Kishen, *Indian For.*, 1951, **77,** 699).

LOPHOPOGON Hack. (*Gramineae*)

Fl. Br. Ind., VII, 149; Blatter & McCann, 28, Pl. 19.

An Indo-Malayan genus of small, perennial, densely tufted grasses, of which three species are found in India.

L. tridentatus Hack., a small annual or perennial grass, with slender, tufted stems, 10–45 cm. high, and rigid leaves, is found usually in dry, gravelly uplands in Madhya Pradesh, Deccan, Konkan and Kanara up to 720 m. It is a useful fodder grass and cattle nibble it only before flowering. Analysis of grass gave the following values (air dry basis): moisture, 7.76; protein, 2.37; carbohydrates, 39.58; fat, 1.51; fibre, 29.17; and ash, 19.61% (Ranga Achariyar, 168; Jacob, *Madras agric. J.*, 1939, **27,** 9; Ramiah, *Bull. Dep. Agric. Madras*, No. 33, 1941, 14).

Loquat — *see* **Eriobotrya**

Loranthus — *see* **Dendrophthoe, Macrosolen**

LORIS (Class *Mammalia*, order *Primates*, sub-order *Prosimii*, family *Lorisidae*)

Fn. Br. Ind., Mammalia, 1939, I, 164–85.

Lorises are small, quadrumanous ape-like animals, mostly arboreal and nocturnal in habit, found in the Indo-Malayan region. They are characterized by their huge staring eyes, rudimentary tail and imperfectly developed index fingers; the coat is covered by soft fur. The digits of hands and feet, the well-padded palms and soles, and the short hairy heels are well adapted to give them a tenacity of grip unequalled in other primates. Lorises are represented in India by a single race of *Nycticebus coucang* Bodaert (Slow Loris) and two races of *Loris tardigradus* Linn. (Slender Loris). These animals and their skeletons are in demand and are exported to various zoological gardens and museums.

Nycticebus coucang bengalensis Fischer (HINDI—*Sharmindi billi*; BENG. *Lajjar banar, lajjowati banar*) inhabits the dense forests of Naga and Lushai hills of Assam. Compared to other races, this slow loris is somewhat larger in size (combined length of head and body, 35–37 cm.; wt., c. 1.1 kg.). Its movements are slow, deliberate and wavering; it sleeps with its head and hands tucked in between the thighs.

Photo: E. P. Walker, New York Zoological Society

FIG. 59. SLOW LORIS—NYCTICEBUS COUCANG BENGALENSIS

New York Zoological Society

FIG. 60. SLENDER LORIS—LORIS TARDIGRADUS LYDEKKERIANUS

Though savage in the early stages of captivity, it can be turned to a docile pet. Tribal people are reported to use the fur of the animal for stopping bleeding from wounds.

Loris tardigradus lydekkerianus Cabrera (HINDI—*Sherminda*; MAR.—*Wanur manushya*; TEL.—*Devanga pilli*; TAM.—*Tevangu, kattu pullaye*; KAN.—*Kadu papa, nala manushya*; COORG—*Chinge kuli*) is found in the forests of eastern ghats up to an altitude of 900 m., extending westwards to Mysore. It is distinguished from the slow loris by its lean lanky appearance and long slender limbs (combined length of head and body, 22–27 cm.; wt., 220–350 g.). Slender loris is a victim of the superstition that its lustrous eyes are a love charm and a cure for eye troubles; a good number of animals are caught and sold alive. *L. t. malabaricus* Wroughton (COORG *Hunimunna, singalika, kadu manushya*) occurs in south Coorg, Malabar, Wynaad and Travancore, up to an altitude of 870 m.; it is smaller than *L. t. lydekkerianus* (Jerdon, 14–16; Sterndale, 22–24; Prater, 20–21; Ellerman & Morrison-Scott, 190–92).

LOTUS Linn. (*Leguminosae*)

A fairly large genus of herbs distributed mainly in Europe, Africa, Asia and Australia; the American

species, though kept by many authors under a separate genus, are considered to be in no way different and are recommended for inclusion in this genus. Three species are recorded in India, of which two are indigenous; *L. jacobaeus* Linn., an introduced species, is cultivated in Indian gardens (Callen, *Canad. J. Bot.*, 1959, **37**, 157; Firminger, 564).

L. corniculatus Linn. BIRDSFOOT TREFOIL

Fl. Br. Ind., II, 91; Blatter, I, 79, Pl. 18, Fig. 4.

A perennial herb with slender glabrous stem, c. 30.0 cm. high, distributed in the Himalayas from Kashmir to Nepal up to an altitude of 3,000 m. Leaves compound: leaflets 5, lower pairs resembling stipules; flowers golden yellow, in axillary umbels; pods cylindrical, 2.50–4.0 cm. long, enclosing several seeds: seeds plumpy, bright, shining olive-brown.

L. corniculatus is a very variable species. It is common in open glades of woods and hillsides in Kashmir. Though indigenous to India, it has not attained much importance as a pasture plant. In America, Africa and Australia, however, it is widely grown as a component of mixed pastures. It is fairly hardy and shows a wide range of adaptability to climatic and soil conditions; in tolerance to drought and high concentration of salt, it is superior to clover or lucerne. It is a good soil binder and is not affected by any serious pest or disease. It is slow in growth and needs the support of a grass cover to prevent it from lodging. It maintains superior feeding value with advancing maturity better than most other forages (Ahlgren, 108; Robinson, 65; Whyte *et al.*, 287; Panikkar, *Indian Fmg*, 1949, **10**, 444).

Birdsfoot trefoil is palatable to animals and may be used in pasture or fed as silage or hay. In composition and nutritive value, it compares favourably with lucerne and white clover. It does not cause bloat in cattle, as lucerne sometimes does; it contains hydrocyanic acid but only in traces and is not toxic to animals. Analysis of pasture and hay from U.S.A. gave the following values: *pasture*—total dry matter, 20.0; protein, 5.6; fat, 1.0; N-free extr., 9.3; fibre, 2.6; and mineral matter, 1.5%: *digestible nutrients*—digestible protein, 4.6; total digestible nutrients, 15.0%; nutritive ratio, 2.3; *hay*—total dry matter, 91.2; protein, 14.2; fat, 2.1; N-free extr., 41.9; fibre, 27.0; mineral matter, 6.0; calcium, 1.6; phosphorus, 0.20; and potassium, 1.66%: *digestible nutrients*—digestible protein, 9.8; total digestible nutrients, 55.0%; nutritive ratio, 4.6. The hay is a good source of carotene (7.3 mg./100 g.). Feeding trials have shown that milk from cows fed on trefoil hay contains more of vitamins A and E than that from cows given lucerne hay (Ahlgren, 111–13; Panikkar, loc. cit.; Morrison, 325, 1020, 1002–03; Loosli *et al.*, *J. Dairy Sci.*, 1950, **33**, 228).

The flowers and leaves of the plant contain a colouring matter which imparts an orange-yellow colour to aluminium-mordanted cotton. The flowers constitute an important source of nectar for honey bees in Britain. They contain α-carotene, β-carotene, xanthophyll, xanthophyll epoxide, violaxanthin and an unidentified carotenoid. The seeds yield 6.5% of a fatty oil (Perkin & Everest, 636; *Indian Bee J.*, 1953, **15**, 115; Karrer & Jucker, 71; Wehmer, I, 533).

Lotus, Sacred — *see* **Nelumbo**

Love Grass — *see* **Eragrostis**

Lovi-Lovi — *see* **Flacourtia**

Loxa Bark — *see* **Cinchona**

Lucerne — *see* **Medicago**

LUCULIA Sweet (*Rubiaceae*)

D.E.P., V, 93; Fl. Br. Ind., III, 36.

A small genus of shrubs or small trees distributed from Himalayas to China. Three species are found in India.

L. gratissima Sweet (NEPAL—*Dowari*; LEPCHA—*Simbrangrip, sabrak-rik*) is a large ornamental shrub or small tree, up to 5 m. in height, found in the Himalayas from Nepal to Bhutan and in Lushai hills at altitudes of 1,200–1,800 m. Bark thin, grey; leaves ovate-oblong, very variable; flowers in terminal corymbs, pink, very fragrant; capsule obovoid. The leaves of this species are reported to be used in dyeing, alone or mixed with those of *Hedyotis* spp. (q.v.). The wood (wt., 23 lb./cu.ft.) is white, moderately hard, close- and even-grained. The flowers are used by local people for decoration (Gamble, 408).

Luculia spp., especially *L. gratissima*, are valued in England and America as winter shrubs for house decoration and conservatories. They are propagated by stem cuttings (Bailey, 1947, II, 1918; Chittenden, III, 1210).

***LUDWIGIA** Linn. (*Onagraceae*)

Fl. Br. Ind., II, 588.

A genus of annual or perennial, aquatic or semi-aquatic herbs distributed mostly in N. America; a

*Some authors amalgamate this genus with *Jussiaea* Linn. (Brenan, *Kew Bull.*, 1953, 163).

few species are found in tropical Africa, tropical Asia and Australia. Two species occur in India.

L. perennis Linn. syn. *L. parviflora* Roxb. (MUNDARI —*Sukuri pota, gara sirgiti*) is a herbaceous, erect annual, found throughout the greater part of India usually in rice fields, moist areas and river banks. The plant, boiled with oil, is used by Mundas as an external application on the body for reducing fever. *L. prostrata* Roxb. (MUNDARI— *Huring rangaini*) is a prostrate or decumbent herb found in rice fields and swamps in the upper Gangetic plain, Bihar, Sikkim terai, N. Bengal, Aka hills (Assam) and western ghats up to 600 m. The leaves of the plant are reported to be used by Mundas for aching muscles and toothache (Bressers, 66).

LUFFA Linn. (*Cucurbitaceae*)

A small genus of herbaceous climbers mainly indigenous to the tropics of the Old World. Four or five species are found wild in India. Some are grown for their edible fruits while a few are of medicinal value: one yields the well-known Loofah Sponge.

L. acutangula (Linn.) Roxb. RIDGED OR RIBBED GOURD

D.E.P., V, 94; Fl. Br. Ind., II, 615; Chakravarty, *Rec. bot. Surv. India*, 1959, **17**(1), 79.

SANS.—*Jhongaka, koshataki*; HINDI—*Kali tori, jhinga tori*; BENG.—*Jhinga, sataputi*; MAR.—*Shirola*; GUJ.—*Ghisoda*; TEL. -*Birakaya*; TAM.—*Pirkankai*; KAN. -*Hirekayi*; MAL. -*Pichenga*.

A large climber with palmately 5–7 angled or lobed leaves found wild in northwest India, Bihar, Bengal, Sikkim and Assam, and also in Madras. Plants monoecious; male flowers with 3 stamens, in 10 to 20-flowered racemes, female flowers solitary, in same axils as males; fruits 15–30 cm. long (rarely up to 1 m. or more), cylindrical or club-shaped, with 10 prominent almost wing-like, longitudinal ribs or ridges; seeds much compressed, 10–12 mm. long, slightly corrugated on edges, black when ripe.

Ridged gourd is cultivated throughout India. A strain grown in Bihar, and locally known as *Satputria* or *Satputiya*, bears hermaphrodite flowers and fruits in clusters. A cross of *Satputiya* with the common monoecious strain is reported to yield five times as much fruit as the monoecious parent; unlike the *Satputiya* parent, it is suitable for summer cultivation. *Pusa Nasdar*, a strain evolved from the common cultivated form, is reported to be early maturing; it produces club-shaped fruits of good length and is suitable for cultivation in summer [Singh *et al.*, *Nature, Lond.*, 1948, **161**, 775; Richharia, *Proc. Bihar Acad. agric. Sci.*, 1952, **1**, 1; Singh & Sikka, *Indian Fmg, N.S.*, 1955-56, **5**(5), 25].

I.A.R.I., New Delhi

FIG. 61. LUFFA ACUTANGULA—FRUITS

Ridged gourd thrives in all types of soils and responds well to manuring. Manure is generally added to the crop preceding it. Application of farmyard manure at 10 cartloads per acre, supplemented with 200 lb. of a mixture of superphosphate and ammonium sulphate in the proportion of 2 : 1, is considered beneficial. Two crops are raised in a year, one early (summer crop) and another late (monsoon or autumn crop). Early sowings are made in February–March on patches or hills 3 ft. apart each way; irrigation at intervals of 4–5 days is necessary. The plants are allowed to trail over the ground without any support. Late sowings are made in June–July in rows 5–6 ft. apart, the distance between sowings in the row being 8–12 in. Plants are staked up when they are a few inches tall. In areas with mild winters, sowings are possible practically throughout the year

(Firminger, 152; Gollan, 88; Purewal, 75; Singh & Sikka, loc. cit.).

Flowering starts *c.* 60 days after sowing; the summer crop is ready for harvest in May–August and the monsoon crop in September–December. Shoots are pinched back to induce fruit setting. Fruits are picked when still tender. Under ordinary conditions of cultivation, each plant yields 15–20 fruits: a higher yield is obtained with liberal applications of manure (Gopalaswamiengar, 556; Singh & Sikka, loc. cit.).

The crop is susceptible to fruit rot caused by *Pythium aphanidermatum* (Eds.) Fitzpatrick and downy mildew caused by *Pseudoperonospora cubensis* (Berk. Curt.) Rostov. It is also susceptible to leaf curl. The mode of infection and method of control are the same as those described for *Lagenaria* (q.v.).

Seedlings and older plants are subject to attack by the red pumpkin beetle *Aulacophora foveicollis* Lucas. Dusting with cowdung ash in the morning when leaves are wet with dew or dusting with hydrated lime or a mixture of lime and tobacco dust is reported to be effective. Periodic dusting with a 1:8 mixture of Paris green and ash, or a 1:30 mixture of lead arsenate and ash, is also recommended. Dusting with DDT or BHC in weak doses (3%) has given encouraging results, but is not recommended as the plants are sensitive to the insecticides and show phytotoxic symptoms. The fruit fly *Dacus diversus* Coquillett is a serious pest of autumn crops; the flies can be trapped in shallow vessels containing water and a few drops of citronella oil; infested fruits should be destroyed. *Poecilocerus pictus* Fabr., a grasshopper common on *Calotropis* spp., damages the leaves. Spraying with calcium or sodium arsenite at 1 lb. and ½ lb. per 100 gallons of water affords satisfactory control [Singh & Sikka, loc. cit.; Narayanan, *Indian Fmg, N.S.*, 1953–54, **3**(2), 8; Pruthi & Nigam, *Indian J. agric. Sci.*, 1939, **9**, 629; Bindra, *Indian J. Hort.*, 1958, **15**, 80].

Ridged gourd is a popular vegetable and is eaten when tender: on ripening, it becomes fibrous and unpalatable. Analysis of the edible part of the fruit gave the following values: moisture, 95.4; protein, 0.5; fat (ether extr.), 0.1; carbohydrates, 3.7; mineral matter, 0.3; calcium, 0.04; and phosphorus, 0.04%; iron, 1.6 mg./100 g.; carotene (as vitamin A), 56 i.u./100 g.; iodine and phytin are present. The non-protein nitrogen accounts for 48.8% of the total nitrogen; the following amino acids have been identified in the free state: arginine, glycine, threonine, glutamic acid, leucines, serine, alanine, γ-amino butyric acid and pipecolic acid (*Hlth Bull.*, No. 23, 1951, 40; Iodine Content of Foods, 77; Winton & Winton, II, 470; Kulkarni & Sohonie, *Indian J. med. Res.*, 1956, **44**, 511; Rao *et al.*, *J. sci. industr. Res.*, 1956, **15C**, 39).

Ripe seeds of ridged gourd (wt., 19 g./100 seeds) contain bitter principles, designated as cucurbitacins B, D, G and H. The molecular formulae of the first three are, respectively, $C_{32}H_{48}O_8$ (m.p. 184–86°), $C_{30}H_{46}O_7 \cdot \frac{1}{2}H_2O$ (m.p. 151–52°) and $C_{30}H_{52}O_9$ (m.p. 149–50°); cucurbitacin H has not been crystallized. Cucurbitacin B is the major constituent and it is probably identical with the principle described in the older literature and isolated from *L. acutangula* var. *amara* and *L. cylindrica*. The perisperm separated from germinating seeds contains a high concentration of cucurbitacins B and D. A saponin which gives oleanolic acid on hydrolysis has also been separated from the seeds. The roots contain cucurbitacin B and traces of cucurbitacin D (Barua *et al.*, *J. Indian chem. Soc.*, 1958, **35**, 480; Enslin *et al.*, *J. Sci. Fd Agric.*, 1957, **8**, 673; Rehm *et al.*, ibid., 1957, **8**, 679).

The seed kernel (51% of seed wt.) contains (dry basis): crude protein, 39.88; fat, 48.41; fibre, 1.89; pentosans, 2.24; reducing sugars, 3.61; and ash, 4.77%; the ash contains *c.* 25% P_2O_5. Ripe seeds yield 19.9% of a clear light brown oil with the following characteristics: n^{25}, 1.4631; sap. val., 188.5; iod. val. (Wijs), 95.7; free fatty acids (as oleic), 1.1%; and unsapon. matter, 1.0%. The component fatty acids of the oil are: saturated, 24.13; oleic, 38.78; and linoleic, 37.09% (Adriaens, 292; Wehmer, II, 1195; Chakrabarty *et al.*, *Naturwissenschaften*, 1955, **42**, 344).

The leaves of the plant are used as poultice in haemorrhoids, leprosy and splenitis; the juice of fresh leaves is reported to be useful in granular conjunctivitis in children. A decoction of the leaves is used in Java for uraemia and amenorrhoea. Ripe seeds are bitter; they are reputed to possess emetic and purgative properties. The seed oil and cake are toxic. The cake is rich in nitrogen and phosphorus and may be used as manure (Kirt. & Basu, II, 1122; Burkill, II, 1371; Porterfield, *Econ. Bot.*, 1951, **5**, 3; Grewal & Kochhar, *Indian J. med. Res.*, 1943, **31**, 63; *Bull. imp. Inst., Lond.*, 1929, **27**, 109).

Luffa acutangula (Linn.) Roxb. var. **amara** (Roxb.) C. B. Clarke

D.E.P., V, 95 : Fl. Br. Ind., II, 615 : Chakravarty, *Rec. bot. Surv. India*, 1959, **17**(1), 81.

SANS.—*Katukoshataki, tiktakoshataki ;* HINDI—*Karvitori ;* BENG.—*Titodhundul, titotorai ;* MAR.—*Ranturai, kadudodaka ;* GUJ.—*Kadvighisodi ;* TEL.—*Adavibira ;* TAM.—*Peypirkam ;* KAN.—*Kaduhire ;* MAL.—*Athanga.*

A fairly large climber found in western, central and southern India, and regarded as the wild form of the cultivated species. It resembles *L. acutangula* in every respect, except that the leaves, flowers, fruits and seeds are smaller. Fruit obovoid, 10-ribbed, obtusely conical at both ends, 5–10 cm. long and 2.5–3.8 cm. thick. The plant flowers towards the close of the rainy season and fruits during winter.

All parts of the plant are exceedingly bitter. A crystalline bitter principle (yield, 0.12%), identical with cucurbitacin B, has been isolated from the seeds. The seeds yield 18.4% of a reddish brown fatty oil with the following characteristics: sp. gr.$^{30°}$, 0.9131 ; n_D^{25} , 1.4730 ; iod. val. (Hanus), 105.3 ; sap. val., 192.7 ; acid val., 18.41 ; R.M. val., 0.26 ; Hehner val., 89.30 ; acet. val., 11.62 : and unsapon. matter, 1.5%. The fatty acids present in the oil (saturated, 19.34 : unsaturated, 80.3%) are palmitic, stearic, oleic, linoleic and a trace of lignoceric (Chaudhry *et al., J. sci. industr. Res.*, 1951, **10B,** 26 ; Chaudhry & Halsall, *Chem. & Ind.*, 1959, 1119 ; *Chem. Abstr.*, 1953, **47,** 890).

The plant possesses laxative and purgative properties and is reported to be useful in skin diseases and asthma. It is used as a diuretic and given in splenic enlargements. The dried fruit is powdered and used as snuff in jaundice. Seeds are considered emetic, expectorant and demulcent. Leaves are applied externally to sores in cattle (Kirt. & Basu, II, 1124 ; Koman, 1920, 6).

L. cylindrica (Linn.) M. J. Roem. syn. *L. aegyptiaca* Mill. SPONGEGOURD, VEGETABLE SPONGE

D.E.P., V, 96 ; Fl. Br. Ind., II, 614 ; Chakravarty, *Rec. bot. Surv. India*, 1959, **17**(1), 75.

SANS.—*Rajakoshataki, dirgha patolika ;* HINDI—*Ghiya tori ;* BENG.—*Dhundal ;* MAR.—*Ghosali ;* GUJ.—*Turia ;* TEL.—*Guthibira ;* TAM.—*Mozhuku pirkankai ;* KAN.—*Tuppahirekai ;* MAL.—*Kattupeechal.*

A large climber similar to *L. acutangula* in habit, but differing from it mainly in having five stamens in the flower and in the shape of fruit and seed. Fruit

I.A.R.I., New Delhi

FIG. 62. LUFFA CYLINDRICA—FRUITS

smooth, cylindrical, usually 20–50 cm. long, rarely reaching 250 cm. ; seed narrowly winged, blackish.

Spongegourd is said to be indigenous to India. Both edible and bitter forms are known and the former, said to have been evolved through cultivation, is widely grown in all sub-tropical parts of the world. A large number of types adapted for cultivation during different seasons are known. *Pusa Chikni* is reported to be a good cropper maturing in 45 days and suitable for cultivation during spring as well as summer. A seedless variety with slender fruits is grown in Africa (Singh & Sikka, loc. cit. : Dalziel, 61).

The plant is cultivated in the same way as *L. acutangula* and is subject to the same diseases and pests (Singh & Sikka, loc. cit. ; Narayanan, loc. cit.).

Tender fruits of spongegourd are used as vegetable. On maturing, the fibrovascular bundles harden and the pulp becomes bitter and inedible. Analysis of the edible part of the tender fruit gave the following values: moisture, 93.19 ; protein, 1.21 ; ether extr., 0.23 ; carbohydrates, 2.93 ; fibre, 1.95 ; and ash,

0.49%: calcium, 36 mg.; phosphorus, 19 mg.; and iron, 1.1 mg./100 g.; carotene (as vitamin A), 200 i.u.; thiamine, 17.55 μg.; riboflavin, 63.17 μg.; and niacin, 0.37 mg./100 g.; ascorbic acid, trace; the fruit contains choline (choline chloride, 10.45 mg./g.) and phytin. The non-protein nitrogen forms 23.5% of the total nitrogen; the following free amino acids have been identified: lysine, arginine, aspartic acid, glycine, threonine, glutamic acid, alanine, tryptophan, phenylalanine and leucines (Porterfield, *Econ. Bot.*, 1951, **5,** 34; *Rep. Dep. Nutr. Govt. Bombay*, 1957, 24; Winton & Winton, II, 470; Ahmad *et al.*, *Indian J. med. Res.*, 1953, **41,** 441; Kulkarni & Sohonie, ibid., 1956, **44,** 511).

Seed kernels (51% of the wt. of seeds) contain: nitrogenous matter, 40.94; fat, 45.72; fibre, 2.89; pentosans, 2.31; reducing sugars, 3.11; mineral matter, 4.75; and phosphorus (P_2O_5), 1.83%. The oil obtained from the kernels is dark red in colour with a faint odour and agreeable taste; it has the following characteristics: sp. gr.$^{27°}$, 0.9412; $n^{27°}$, 1.4830; sap. val., 194.90; iod. val., 106.4; acid. val., 7.99; acet. val., 17.95; R.M. val., 0.59; Polenske val., 1.18; and unsapon. matter, 1.2%. The fatty acid composition of the oil is as follows: palmitic, 9.58; stearic, 7.35; oleic, 40.49; and linoleic, 42.58%. The seeds contain a bitter crystalline substance, probably identical with cucurbitacin B. A crystalline saponin (m.p. 271° decomp.) which on hydrolysis yields oleanolic acid, galactose, arabinose, xylose and rhamnose has been isolated [Adriaens, 292; Wehmer, II, 1196; Dalziel, 60; Phadnis *et al.*, *J. Univ. Bombay*, 1948, **17A**(24), 62; Rangaswami & Sambamurthy, *Indian J. Pharm.*, 1954, **16,** 325; Enslin *et al.*, *J. Sci. Fd Agric.*, 1957, **8,** 673; Barua, *Sci. & Cult.*, 1957–58, **23,** 154].

Young leaves of the plant are used as pot-herb in Africa. A clear liquid, useful in respiratory complaints, is extracted in Japan from the stem by making incisions *c.* 1 in. above the ground. The tender fruit is considered diuretic and lactagogue. Ripe fruit is used in China, after burning and pulverizing, as carminative and anthelmintic; the juice of the fruit is purgative. Mature seeds are bitter, emetic and cathartic. The seed oil may be used as a substitute for olive oil; it is said to be useful for skin affections. The bitter seed cake may be used as manure (Dalziel, 61; Porterfield, *Econ. Bot.*, 1955, **9,** 211; Kirt. & Basu, II, 1121).

Loofah sponge—The fibro-vascular network of the ripe fruit affords a sponge widely used for scrubbing and cleaning purposes. It is extracted on a commercial scale in Japan and exported mainly to Germany, U.K. and U.S.A. During World War II, when supplies from Japan were unavailable, *L. cylindrica* was cultivated in S. American countries with a view to produce loofah sponge for U.S. markets. The quality of the product, however, was poor. Supplies from Japan to U.S. have since been resumed. Loofah sponge is produced in India and is reported to be of satisfactory quality (Porterfield, *Econ. Bot.*, 1955, **9,** 211).

For obtaining loofah sponge, cultivators in Japan train the vines over trellises so that the developing fruits are assured of maximum exposure to sun; the fruits are prevented from being discoloured and distorted by contact with the ground. Side branches are pruned at an early stage to encourage the growth of the main stem, and early male flowers and even female flowers are removed. About 20–25 fruits are retained on each vine and they are harvested at maturity as indicated by the yellowing of base and apex. The average yield is reported to be 24,000 fruits

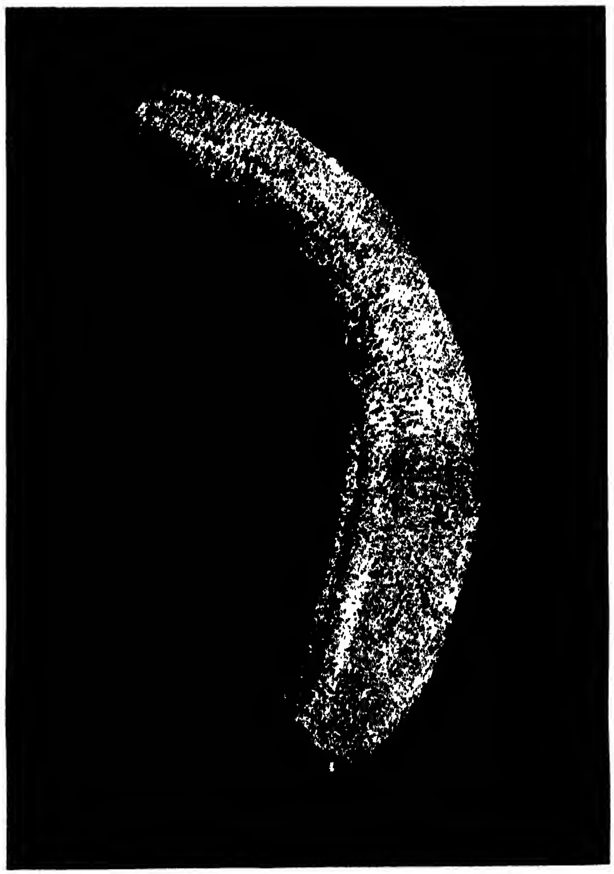


FIG. 63. LUFFA CYLINDRICA—SPONGE

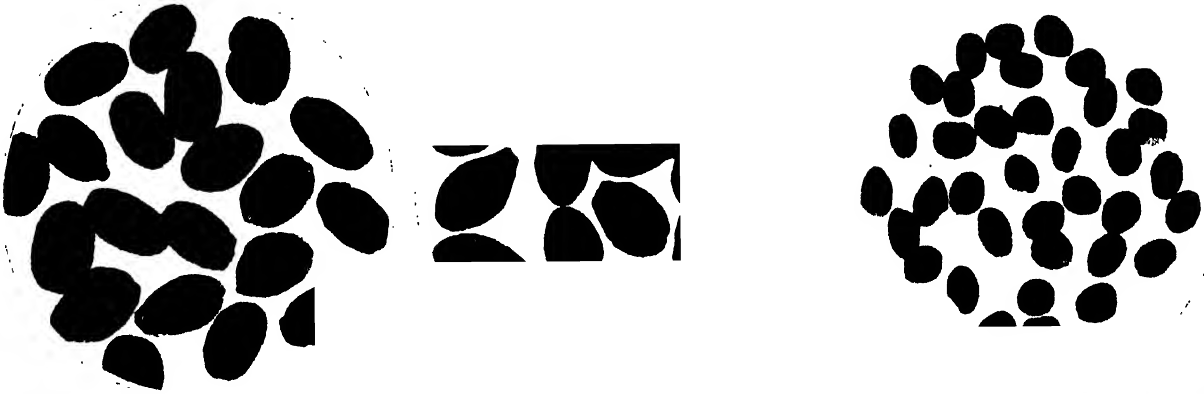


FIG. 64. SEEDS OF L. CYLINDRICA, L. ACUTANGULA AND L. ECHINATA *I.A.R.I., New Delhi*

per acre (Porterfield, *Econ. Bot.*, 1955, **9**, 211 ; Ingram, *Colon. Pl. Anim. Prod.*, 1952–53, **3**, 165).

Harvested fruits are immersed in tanks of running water till the outer walls disintegrate and are removed. They are washed to remove seeds and pulp clinging to fibres. Cleaned sponges are left exposed for bleaching and drying ; they are further bleached with hydrogen peroxide, graded and packed into bales, 3 ft. × 2 ft. × 18 in., for export. As the removal of seeds from dried gourds is a time consuming process, attempts have been made to produce fruits free of seeds, by application of growth substances like indoleacetic acid before pollination (Porterfield, *Econ. Bot.*, 1955, **9**, 211 ; Ingram, loc. cit.).

Loofah sponges are widely used as bath sponges. They are useful for cleaning motor cars, glassware and kitchen utensils. They possess fairly good shock and sound absorbing properties ; they have been used in steel helmets and armoured vehicles in U.S.A. They are also used for stuffing pillows, mattresses, saddles and shoulder pads. Loofah sponges possess heat insulating properties and are useful for making pot holders and table mats. Combined with plaster and varnished over, they make sound-proof and heat-proof wall boarding. They are preferred as filters in marine steam engines and internal combustion engines and used as substitutes for cellulose sponges, turkish towelling and spanish moss. They are a good source of cellulose and have been tried as possible raw material for paper pulp (Porterfield, *Econ. Bot.*, 1955, **9**, 211 ; Dalziel, 61 ; Wehmer, II, 1196).

L. echinata Roxb.

D.E.P., V, 97 ; Fl. Br. Ind., II, 615 ; Chakravarty, *Rec. bot. Surv. India*, 1959, **17**(1), 77 ; Kirt. & Basu, Pl. 450.

SANS.—*Koshaphala, devadalika* ; HINDI & BENG.—*Bindal* ; MAR.—*Devadali, devadangari* ; GUJ.—*Kukaravel.*

A climber with a slender, slightly hairy, furrowed stem and 2-fid tendrils occurring wild in U.P., Bihar, Bengal and Gujarat. Leaves orbicular reniform, obscurely 5-angled or more or less deeply 5-lobed ; male peduncles normally paired, one being 1-flowered and the other a long raceme of 5–12 flowers at apex ; female flower solitary ; fruit oblong or globose, c. 3 cm. long, not ribbed, clothed with ciliate bristles ; seeds many (c. 18), 5 mm. long. A variety of this plant, *L. echinata* Roxb. var. *longystyla* Clarke syn. *L. longystyla* Edgew., is recorded from Banda ; it differs from the type in having shorter male racemes and fewer bristles on the

The fruit is intensely bitter and fibrous. It has purgative properties. It is reported to be used for dropsy, nephritis, chronic bronchitis and lung complaints. An infusion of the fruit is given in biliary and intestinal colic ; it is applied to the body in putrid fevers and jaundice (Kirt. & Basu, II, 1126 ; Nadkarni, I, 754 ; Bhatt & Khorana, *Indian J. Pharm.*, 1957, **19**, 208 ; Duthie, I, 367).

The fruit contains a crystalline bitter principle, echinatin (m.p. 174° ; yield, 0.33%) and a saponin. The seeds yield 11.1% of a yellow or brownish red fatty oil with the following characteristics: sp. gr.$^{32°}$, 0.9157 ; n^{31}, 1.4725 ; sap. val., 143.0 ; acet. val., 27.3 ; iod. val., 94.52 ; acid val., 63.96 ; R.M. val., 1.95 ; Hehner val., 95.45 ; and unsapon. matter, 2.76%. The oil consists of 25% saturated and 75% unsaturated acids (Bhatt & Khorana, loc. cit. ; Nigam *et al.*, *Curr. Sci.*, 1949, **18**, 451).

L. graveolens Roxb.

Fl. Br. Ind., II, 614; Chakravarty, *Rec. bot. Surv. India*, 1950, **17**(1), 74.

A slender climber with 3- to 5-fid tendrils found in Bihar, Bengal, eastern Himalayas and Sikkim. Leaves 5-angled, reniform, orbiculate; flowers yellow: fruit beaked when young, ellipsoid or oblong when mature, covered with soft spines, dehiscing horizontally near top; seeds numerous, oval, compressed, black, 6 mm. long.

The seeds yield 11.6% of a yellow or brownish red fatty oil with the following characteristics: sp. gr.^{37}, 0.9594: n^{31}, 1.4740; sap. val., 197.2; acet. val., 75.06; iod. val., 96.70; acid val., 47.75; R.M. val., 3.32; Hehner val., 92.45; and unsapon. matter, 0.29%. The oil consists of 20.78% saturated and 79.22% unsaturated acids. The fruits contain a bitter principle (Nigam *et al.*, loc. cit.; Wehmer, II, 1196).

LUISIA Gaudich. (*Orchidaceae*)

Fl. Br. Ind., VI, 22.

A small genus of tufted epiphytic orchids distributed from tropical Asia to New Caledonia and Japan. About 20 species occur in India.

L. brachystachys Blume is a slender orchid found in tropical Himalayas in Garhwal and Kumaon up to 1,500 m., Khasi hills and Sundarbans. The plant is reported to contain traces of an alkaloid (Wehmer, I, 190).

L. tenuifolia Blume is a slender orchid found in western ghats from Konkan southwards to Kerala, Shevaroy hills and S. Arcot, ascending up to 1,200 m. The crushed plant is used as an emollient and applied as poultice to boils, abscesses and tumours (Caius, *J. Bombay nat. Hist. Soc.*, 1935-36, **38**, 796).

L. trichorrhiza Blume (Mundari—*Arajora*) is a stout orchid found in tropical Himalayas in Garhwal and Sikkim, Bihar and Chota Nagpur. The plant is used in external applications for muscular pains (Bressers, 153).

Lukrabo Oil — *see* **Hydnocarpus**

LUMNITZERA Willd. (*Combretaceae*)

A small genus of evergreen mangrove trees or shrubs distributed on the tropical coasts of the Old World and Polynesia. Two species are found in India.

L. littorea Voigt syn. *L. coccinea* Wight & Arn.

Fl. Br. Ind., II, 452; Fl. Malesiana, Ser. I, **4**(5), 586, Fig. 32.

A small handsome tree found on the coastal regions of Andaman and Nicobar Islands. Bark reddish brown, rough, fissured, peeling off in flakes; leaves crowded at the ends of branches, obovate to oblanceolate; flowers in terminal racemes, scarlet; fruit ellipsoid, somewhat corky.

The wood is brownish grey with rose-like odour when fresh; it is hard, heavy (wt., 54 lb./cu. ft.), fine- and straight-grained and fine-textured. It seasons well and is very durable. It is easy to work and finishes to a smooth surface, but is difficult to obtain in large pieces. In Malaya and Philippines, it is used for piles, posts, wharves, decks, canoes, ship-building, bridges, general construction, flooring, sleepers, furniture, cabinet work, axles of carts, tool handles and as fuel (Brown, I, 70; Rodger, 6; Burkill, II, 1372–73).

The leaves of the plant are reported to be used for sprue in Malaya. The bark contains 11.8% tannin (Burkill, II, 1373; Wehmer, II, 824).

L. racemosa Willd.

D.E.P., V, 97; Fl. Br. Ind., II, 452; Fl. Malesiana, Ser. I, **4** (5), 588.

Beng.—*Kripa*; Tel.—*Kadivi, thandara*; Tam.—*Tipparathai*; Mal.—*Katakkantal*; Oriya—*Tunda*.

A handsome shrub or a small tree found on the coasts of India and Andaman and Nicobar Islands. Bark reddish brown, rough, exfoliating in scales; leaves crowded at the ends of branches, oblong-obovate or oblanceolate, fleshy: flowers in axillary racemes, small, mostly white, fragrant: fruit oblong-ovoid, 1.25–1.90 cm. long, woody.

The wood (wt., 52–57 lb./cu. ft.) of *L. racemosa* is similar to that of *L. littorea* and can be put to the same uses, but is available in even smaller pieces. It is used as fuel; calorific value: *sapwood*—5,137 cal., 9,247 B.t.u.; *heartwood*—5,454 cal., 9,817 B.t.u. (Brown, 1946, III, 125; Gamble, 348; Burkill, II, 1373; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 19).

The leaves of the plant are eaten in South Pacific Islands during periods of scarcity; they contain: moisture, 88.5; nitrogen, 0.27; ether extr., 4.0; reducing sugars, 0.1; starch, 0.1; fibre, 3.0; and ash, 0.3%. The bark contains 15–19% tannin; leaves and wood contain smaller quantities. A fluid obtained from incisions made in the stem is reported to be employed in external applications for herpes and itches [Peters, *Qualit. Plant. Mat. Veg.*, 1959, **5**, 334;

Peters *et al.*, *Food Res.*, 1960, **25,** 211 ; Edwards *et al.*, *Indian For. Rec. N. S., Chem. & Minor For. Prod.*, 1952, **1** (2), 152 ; Burkill, II, 1373 ; Quisumbing, 654].

Lupine—*see* **Lupinus**

LUPINUS Linn. (*Leguminosae*)

A large genus of annual and perennial herbs, sometimes subshrubs, confined mostly to North and South America, Europe and Africa. None of them have been recorded occurring wild in India.

A few annual lupines are cultivated for green manure and forage, and also as food crops. These include *L. albus* (White Lupine), *L. angustifolius* and *L. hirsutus* (Blue Lupines) and *L. luteus* (Yellow Lupine). They are indigenous to the Mediterranean region whence they have spread to many other countries (Hector, II, 777–78 ; Bailey, 1947, II, 1922 ; Use of Leguminous Plants, 221 ; Whyte *et al.*, 288–89).

Several lupines are poisonous to livestock and are reported to be responsible for heavy losses, especially of sheep, in Europe and America. Poisoning is attributed to the presence of alkaloids, including *d*- and *l*-lupanine ($C_{15}H_{24}ON_2$), lupinine ($C_{10}H_{19}ON$), and *l*-sparteine ($C_{15}H_{26}N_2$). Lupines containing a high percentage of toxic alkaloids are known as Bitter Lupines; they are usually cultivated for green manuring purposes. Lupine strains with low alkaloid content, Sweet Lupines as they are called, have been evolved and are cultivated as fodder or silage crops ; they are also grown for seeds (Chopra *et al.*, 388 ; Steyn, 93–94 ; Manske & Holmes, III, 123–26 ; Henson & Stephens, *Fmrs' Bull. U.S. Dep. Agric.*, No. 2114, 1958 ; Whyte *et al.*, 289 ; Robinson, 87).

Several *Lupinus* species are grown in gardens as winter annuals for their showy flowers. They are suitable for borders, beddings, pot culture and cut flowers (Bailey, 1947, II, 1922 ; Firminger, 561–62 ; Gopalaswamiengar, 444).

L. albus Linn. WHITE LUPINE

D.E.P., V, 98 ; Bailey, 1949, 566.

HINDI—*Turmas* ; BENG.—*Turmuz*.

PUNJAB—*Turmuz, zurmish*.

A herbaceous erect annual, 45–120 cm. high, native of Levant and extensively cultivated in the warmer parts of Europe for green manuring and for seeds. It is grown in gardens in India. Leaves digitate: leaflets obovate-oblong ; flowers white, in terminal racemes ; pods large, stout-beaked, hairy ; seeds nearly orbicular, compressed, whitish (Whyte *et al.*, 289 ; Hector, II, 779).

The seeds of *L. albus* are valued as food and cattle feed and consumed after soaking in water to remove the toxic alkaloids. Analysis of seeds gave the following values: moisture, 10.96 ; protein, 32.81 ; fat, 8.88 ; N-free extr. (including fibre), 44.73 ; sugars, 6.33 ; and ash, 2.62% ; *mineral constituents* (dry basis): potassium, 0.75 ; calcium, 0.33 ; magnesium, 0.28 ; sodium, 0.01 ; phosphorus, 0.25 ; and iron, 0.01%. They contain *d*- and *dl*-lupanine and hydroxylupanine ($C_{15}H_{24}O_2N_2$). The fatty oil from the seeds is edible after refining. Seedlings and stems are rich sources of asparagine. The seeds are medicinal ; they are considered deobstruent, alterative, anthelmintic and carminative (Thorpe, VII, 424 ; Chamberlain, *E. Afr. agric. J.*, 1955 56, **21,** 103 ; Henry, 117, 131 ; *Chem. Abstr.*, 1939, **33,** 6467 ; 1953, **47,** 11394 ; *Econ. Bot.*, 1948, **2,** 219 ; *Chem. Abstr.*, 1955, **49,** 16334).

I.A.R.I., New Delhi

FIG. 65. LUPINUS ALBUS—IN FLOWER

The sweet strain of *L. albus* is grown for fodder. Analysis of freshly cut plant gave the following values: dry matter, 12.9; organic matter, 10.8; protein, 2.8 (digestible protein, 2.4); and fibre, 2.7%; starch equiv., 7.8 lb./100 lb. (Whyte *et al.*, 289; *Nutr. Abstr. Rev.*, 1951–52, **21,** 749).

L. angustifolius Linn. BLUE LUPINE
Robinson, 84.

A bushy annual, 60–90 cm. high, with spreading habit. Leaves digitately compound with long, narrow leaflets; flowers small, blue, in axillary racemes; pods thick, stout containing 4–5 seeds; seeds round or slightly kidney-shaped, plump, mottled, with hard seed coat.

L. angustifolius is a native of the Mediterranean region. It is extensively cultivated in Europe, South Africa, Australia, New Zealand and U.S.A. for fodder and green manuring. It has been introduced into India as a green manure plant for potato crops in Nilgiris. In rotational trials for 3 years (1942–43, 1944–45 and 1946–47) at the Agricultural Research Station, Nanjanad, the yields of potato due to blue lupine manuring showed respectively the following increases per acre: 3,733, 2,966 and 2,850 lb. Blue lupine also serves as cattle feed and provides an excellent cover against soil erosion; it smothers weed growth (Whyte *et al.*, 289; Saptharishi, *Madras agric. J.*, 1955, **42,** 486; *Madras agric. J.*, 1949, **36,** 142).

As a green manure crop, blue lupine is grown between successive crops of potatoes. In Nilgiris, three crops of potato are raised in a year and each of them receives green manure. Seeds are sown at the rate of 60–100 lb. per acre in August, March–April and May June. The crop comes up quickly and it is ploughed in, after 3–4 months, when in flower or just before flowering. A yield of 3–5 tons of green material is obtained per acre. Analysis of the fresh plant gave the following values: N, 0.98; P_2O_5, 1.18; and K_2O, 0.53% [Sastry *et al.*, *Indian J. vet. Sci.*, 1942, **12,** 219; Saptharishi, loc. cit.; *Madras agric. J.*, 1949, **36,** 142; Saptharishi & Azariah, *Indian Fmg, N.S.*, 1956–57, **6** (12), 19].

When grown for seeds, blue lupine takes seven months to mature from the time of sowing. The yield of seeds varies from 500 to 600 lb. per acre. Seeds of bitter blue lupine are used as cattle feed after freeing them from alkaloids; those of sweet blue lupines constitute a good substitute for horse gram and red gram. In the green stage, they can replace peas; when dry, they may be used in place of *dhal* (Sastry *et al.*, loc. cit.; *Madras agric. J.*, 1949, **36,** 142).

Analysis of blue lupine seeds gave the following values: moisture, 13.81; protein, 30.98; fat, 6.41; N-free extr., 34.92; fibre, 11.49; and ash, 2.39%. They contain lecithin, α-amino adipic acid and lupeose. The ash contains: K_2O, 31.90; Na_2O, 0.81; CaO, 9.87; MgO, 10.91; Fe_2O_3, 0.73; P_2O_5, 39.04; SO_3, 5.58; SiO_2, 0.34; and Cl, 0.59% (Winton & Winton, II, 304, 309; Wehmer, I, 526; *Chem. Abstr.*, 1954, **48,** 10842).

The seed proteins contain 2 globulins and an albumin. The essential amino acids present in the two globulins are as follows: *globulin*-1 (N, 17.10%)—threonine, 2.29; valine, 3.50; *iso*leucine, 5.95; leucine, 7.59; phenylalanine, 4.83; histidine, 2.30; lysine, 4.32; and arginine, 13.41%; *globulin*-2 (N, 18.39%)— threonine, 3.68; valine, 4.29; methionine, 0.50; *iso*leucine, 5.59; leucine, 8.44; pheynlalanine, 5.34; histidine, 3.03; lysine, 3.88; arginine, 14.34; and tryptophan, 1.62%. The proteins have high digestibility value (90%). They are deficient in methionine and their biological value is 53% (Joubert, *Biochim. biophys. Acta*, 1955, **16,** 370; Gerritsen, ibid., 1956, **22,** 269; *Chem. Abstr.*, 1935, **29,** 6969).

The seeds yield a dark brown, slow-drying fatty oil with bitter taste; the oil has the following characteristics: sp. gr.$^{15°}$, 0.9463; $n_D^{40°}$, 1.4790; iod. val., 104; sap. val., 183; acid val., 28; hydroxyl val., 9.9; and unsapon. matter, 8.0%. The component fatty acids of the oil are: saturated, 10.0; oleic, 47.5; linoleic, 33.7; linolenic, 1.8; and an unsaturated C_{22} acid, 7.0%. The oil may be used in the preparation of glyptals (*Chem. Abstr.*, 1951, **45,** 9895; 1952, **46,** 9858; Piskur, *J. Amer. Oil Chem. Soc.*, 1952, **29,** 187).

The principal alkaloid of the seeds is *d*-lupanine; hydroxylupanine is also present. Analysis of bitter seeds from Coimbatore gave 0.86% total alkaloids; higher values (up to 2.25% *d*-lupanine) have been reported in seeds grown in other countries. The alkaloid content of seeds from a sweet strain, grown in Nanjanad, was 0.13%; feeding trials on bullocks have shown that raw seeds can be fed safely, up to 3 lb. per day (body wt., *c.* 300 lb.) (Henry, 117; Wehmer, suppl., 122; Sastry *et al.*, loc. cit.; Gordon & Henderson, *J. agric. Sci.*, 1951, **41,** 141).

Germinated blue lupine seeds constitute a rich source of asparagine. They have been employed in

culture media in the commercial production of tuberculin. For the extraction of asparagine, seeds are germinated for 12–20 days, and the juice pressed out from seedlings is concentrated *in vacuo* till crystals of asparagine begin to separate. Asparagine is purified by recrystallization from water; 100 lb. of seeds yield 10–16 lb. of asparagine (*Econ. Bot.*, 1948, **2,** 219).

L. luteus Linn. YELLOW LUPINE

Bailey, 1947, II, 1923, Fig. 2218.

An erect annual herb, 30–60 cm. high, native of Mediterranean region and grown as green manure or fodder crop in Europe, S. Africa and N. America. It is grown in gardens in India. Leaves compound: leaflets linear-lanceolate; flowers yellow, whorled in long terminal racemes; pods oblong, flat containing several large seeds.

L. luteus is toxic to grazing animals and is reported to have caused many deaths among sheep in India. All parts of the plant contain alkaloids: seeds contain lupinine (0.43-0.73%) and sparteine (0.20–0.37%); vegetative parts contain other alkaloids. Seeds are feebly cyanogenetic (Lander, 252; *J. Pharm., Lond.*, 1955, **7,** 614; Thorpe, VII, 418; Wokes & Willimott, *J. Pharm., Lond.*, 1951, **3,** 905).

Sweet strains containing very low percentages of alkaloids have been evolved and used for fodder and also silage. Analysis of fresh plant gave the following values: dry matter, 10.4; organic matter, 8.4; protein, 2.3 (digestible protein, 2.0); and fibre, 1.7%; starch equiv., 6.5 lb./100 lb. Seeds contain: dry matter, 88.9; protein, 39.8; fat, 4.9; N-free extr., 25.7; fibre, 14.0; mineral matter, 4.5; calcium, 0.23; phosphorus, 0.39; and potassium, 0.81; digestible protein, 35.4; and total digestible nutrients, 76.9%; nutritive ratio, 1.2. The fatty oil from the seeds is edible after refining (Whyte *et al.*, 289; *Nutr. Abstr. Rev.*, 1951–52, **21,** 749; Morrison, 495, 1056; *Chem. Abstr.*, 1939, **33,** 6467).

L. hirsutus Linn. and *L. mutabilis* Sweet are annual herbs grown in Indian gardens. The latter is regarded as a minor food crop in Peru: the seeds contain 37.7% protein. Sparteine is the principal alkaloid present in the seeds (*Chem. Abstr.*, 1946, **40,** 4156).

Lupulin → *see* **Humulus**

*LUVUNGA Buch.-Ham. (*Rutaceae*)

A small genus of woody climbers found in the Indo-Malayan region. Two species are recorded from India.

L. eleutherandra Dalz. (Fl. Br. Ind.) in part

Fl. Br. Ind., I, 509; Talbot, I, 196, Fig. 120.

A robust, climbing shrub with deflexed spines, found in the western part of Peninsular India, from Konkan southwards to Anaimalai and Travancore hills up to an altitude of 1,000 m. It bears large, 3-foliolate leaves and small, ellipsoid fruits with a rough peel. This species has often been confused with *L. sarmentosa* (Blume) Kurz which occurs in Malaysia. The bark and leaves of this plant are reported to be used, in Java, for aches and rheumatism. The sap from the stem is applied to gums for toothache (Swingle, in Webber & Batchelor, I, 250; Burkill, II, 1374).

L. scandens (Roxb.) Buch.-Ham. ex Wight

Fl. Br. Ind., I, 509; Swingle, in Webber & Batchelor, I, 247; Kirt. & Basu, Pl. 194.

SANS.—*Kakoli*; BENG.—*Lavangalata, lavangaphal.*

A strong woody climber with recurved spines found in Assam and Khasi hills and extending eastwards. Leaves trifoliolate: leaflets lanceolate, thickly coriaceous; flowers white, fragrant; fruit oblong, *c.* 25.0 mm. × 20.0 mm., yellowish, with smooth aromatic peel and resinous, odoriferous pulp; seeds 1–3, ovoid.

L. scandens is an ornamental plant worthy of cultivation in gardens for its conspicuous flowers. Flowers appear in February–April and fruits during August–September. Dried fruits are available in Indian bazaars (particularly in Bengal) under the name *Kakala* or *Sugandhkokila* and used for preparing a perfumed medicinal oil. Four coumarins have been isolated from the petroleum ether extracts of mature fruits; these are: xanthotoxin ($C_{12}H_8O_4$, m.p. 145°), xanthyletin ($C_{14}H_{12}O_3$, m.p. 128°), *iso*-pimpinellin ($C_{13}H_{10}O_5$, m.p. 151–52°), and luvangetin ($C_{15}H_{14}O_4$, m.p. 108–9°). The coumarins are absent in unripe fruits. Mature fruits on steam-distillation yield 2.5% of a yellowish essential oil with the following characteristics: sp. gr.$^{28°}$, 0.945; $n_D^{28°}$, 1.5120; $[\alpha]_D$, −1°; acid val., 1.93; and ester val., 102. The oil contains cinnamyl cinnamate, cineol, *d*-camphor and methyl cinnamate as the main components with small amounts of *l*-pinocamphone, *l*-fenchone, α-citral, *l*-fenchyl alcohol, geraniol, *l*-linalyl acetate, terpinolene, aromadendrene, *d*-limonene, α-*d*-pinene, myrcene and α-*d*-camphene. Three sesquiterpene compounds, designated luvungene ($C_{15}H_{24}$, b.p. 156–

* The correct name for the genus, according to the Intern. Code Bot. Nomenclature, should be *Lavanga* Meissn.

58°/8 mm.), luvungol ($C_{15}H_{24}O$, b.p. 184–87°/8 mm.) and luvungone ($C_{15}H_{22}O$, b.p. 210–15°/5 mm.) have been identified in the oil (Fl. Assam, I, 209; Bose & Mookerjee, *J. Indian chem. Soc.*, 1944, **21**, 181; Baslas & Deshpande, ibid., 1950, **27**, 379; Baslas, *Perfum. essent. Oil Rec.*, 1959, **50**, 124).

An essential oil reported to have been obtained from *Sugandhkokila* berries collected from Garhwal has been recently examined. It differs from the oil derived from the berries of *L. scandens* found in Assam and eastern Himalayas in many of its characteristics. The berries obtained from Garhwal are reported to be brown and black, 0.6–1.2 cm. diam. with wrinkled outer surface. Their identity with *L. scandens* is doubtful (Hattiangdi & Nimbalkar, in *Essential Oils & Aromatic Chemicals, A Symposium*, Coun. Sci. & Industr. Res., New Delhi, 1958, 106).

The seeds yield 10% of a greenish coloured non-drying oil, which solidifies to a crystalline mass on keeping. The characteristics of the oil are as follows: solid. pt., 18.5°; d^{20}, 0.9285; n_D^{20}, 1.4484; sap. val., 227.7; iod. val. (Hanus), 2.93; acid val., 11.41; Hehner val., 93.8; R. M. val., 1.98; and unsapon. matter, 1.52%; fatty acid composition: lauric, 77.38; palmitic, 7.78; myristic, 6.23; capric, 3.14; stearic, 3.0; oleic, 2.4; and caprylic, 0.07% (Baslas, *Indian J. appl. Chem.*, 1960, **23**, 153).

LUZULA DC. (*Juncaceae*)

Fl. Br. Ind., VI, 401; Fl. Malesiana, Ser. I, **4**(3), 214.

A large genus of perennial herbs, rarely annuals, distributed chiefly in the Old World. Four species occur in India.

L. campestris DC. is an erect, slender, tufted, perennial herb with creeping rootstock found in temperate and alpine Himalayas from Kashmir eastwards to Sikkim and Khasi hills, and in Nilgiri, Palni and Anaimalai hills at altitudes of 1,500–4,200 m. The rhizomes are reported to possess diuretic properties (Kirt. & Basu, IV, 2544).

Lychee — *see* Litchi

Lychnis Linn. (*Caryophyllaceae*)

D.E.P., V, 98; Fl. Br. Ind., I, 222.

A genus of herbs distributed in the north temperate and arctic zones and the mountains of South America. About 15 species are found in India; a few exotics are cultivated in hill gardens.

L. coronaria Desr. (Rose Campion, Mullein Pink) is a white-woolly herb, 30–75 cm. high, with spathulate to oblong-lanceolate leaves and purplish or white flowers, commonly met with in Kashmir. A decoction of the roots is used in Spain for liver and lung troubles and for the infraction of lymph glands of the mesentery (Caius, *J. Bombay nat. Hist. Soc.*, 1936–37, **39**, 564).

L. indica Benth. is a dichotomously branched spreading herb found in temperate Himalayas at altitudes of 1,650–3,000 m. The roots and leaves of the plant are used as a substitute for soap.

L. chalcedonica Linn. and *L. viscaria* Linn. are ornamental species cultivated in hill gardens for their beautiful scarlet flowers. The flowers yield a colouring matter which imparts a brilliant red when used with alum mordant. The roots contain a saponin (Firminger, 615; Kierstead, 87, 22; Wehmer, I, 305).

L. githago (Linn.) Scop. = *Agrostemma githago* Linn. (Corn Cockle) is a pubescent herb, native of Europe, with linear-lanceolate leaves, red-purple flowers and black seeds about the size of wheat grains. As the seeds sometimes get mixed with wheat, the plant has spread to various countries and has become a pernicious weed in wheat fields. The seeds are poisonous to human beings and livestock, causing irritation of the alimentary tract, nervous troubles and loss of strength; they prove fatal when consumed in a large amount. The poisonous principle is a saponaceous glycoside. The plant has been introduced into India along with imported wheat and, the need for checking its dispersal has become imperative (Chatterjee & Raizada, *Indian Fmg*, 1950, **11**, 226).

LYCIUM Linn. (*Solanaceae*)

D.E.P., V, 99; Fl. Br. Ind., IV, 240.

A genus of shrubs and trees distributed in the temperate and warm regions of the world. Three species are found in India.

L. barbarum Linn. (Mar.—*Gangro*; Punjab—*Kangu, ganger, chirchitta*; Delhi—*Chirchitta, khatai, chirmethi*; Rajasthan—*Morali*; Saurashtra—*Khichar*) is a spinous shrub, up to 3 m. in height, found in Punjab, Rajasthan, Gujarat and Saurashtra. Leaves mostly in fascicles, very variable, linear-oblong to spathulate; flowers solitary or in fascicles, small, white or purplish; berries bright red, c. 6 mm. in diam. The plant is poisonous to camels and livestock. The leaves contain betaine, traces of a mydriatic alkaloid and hydrocyanic acid. The fresh flowering plant is used as a diuretic in homoeopathy.

Berries are considered to possess aphrodisiac properties; they contain zeazanthin (Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 155; Chopra, 1958, 546; Hocking, 131; Kirt. & Basu, III, 1781; Karrer & Jucker, 76).

L. europaeum Linn. is closely related to *L. barbarum* and has more or less the same distribution; it has been recorded also from Khasi hills. Many authors have confused the two species: and the same vernacular names have been ascribed to them. The berries of *L. europaeum* are eaten: they contain ascorbic acid: oxidases and peroxidases are present. The plant is browsed by camels and goats. Branches are used in the construction of wattled frames for the walls of huts (*Chem. Abstr.*, 1948, **42,** 5510).

L. ruthenicum Murr. (LADAKH—*Khichar, khitsar*) is a small thorny shrub found at high altitudes in north Kashmir. The pea-sized fruits, which are deep reddish purple when ripe, are edible: they are sweet, but mawkish in flavour. The shrub contains an appreciable amount of alkaloids. It is reported to be useful for the treatment of blindness in camels (Kirt. & Basu, III, 1781; *Chem. Abstr.*, 1941, **35,** 4154).

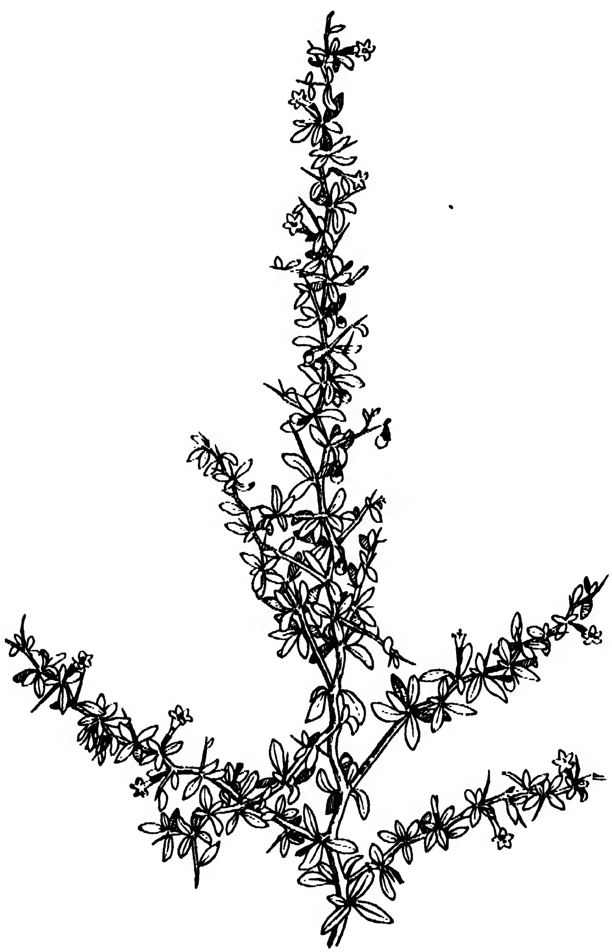


FIG. 66. LYCIUM EUROPAEUM—FLOWERING BRANCH

Lycoperdon — *see* **Fungi**

LYCOPERSICON Mill. (*Solanaceae*)

A small genus of annual or short-lived perennial herbs, indigenous to the western regions of tropical South America. One species, *L. esculentum,* is cultivated throughout the world for its edible fruits.

The genus is divided into two sub-genera, *Eulycopersicon* C. H. Muller and *Eriopersicon* C. H. Muller. The former includes *L. esculentum* (Cultivated Tomato) and *L. pimpinellifolium* (Currant Tomato), both bearing red or yellow edible fruits. *Eriopersicon* includes five species which occur wild and bear small, green or whitish fruits of no economic importance. All species of *Lycopersicon* have 12 pairs of chromosomes in the pollen mother cells (Hector, II, 1019–27; Muller, *Misc. Publ. U.S. Dep. Agric.*, No. 382, 1940, 8; Luckwill, 8, 27, 38, 40–42; Lesley, *Econ. Bot.*, 1948, **2,** 100; Singh & Pal, *Sci. & Cult.*, 1948–49, **14,** 103; *Plant Breed. Abstr.*, 1956, **26,** 2927, 2929).

L. esculentum Mill. TOMATO

D.E.P., V, 100; Fl. Br. Ind., IV, 237.

HINDI & BENG.—*Tamatar, vilayithi baingan*; MAR.—*Vel vangi*; GUJ.—*Vilayithi vengan*; TAM.—*Takkali.*

An unarmed, spreading, pubescent herb with a strong characteristic odour and greyish green, curled, unevenly pinnate leaves, found cultivated throughout the world. Fruits villose when young, glabrous and shining when mature; seeds flat, kidney-shaped and hairy. The shape and size of the fruits and the thickness of pericarp vary in the numerous types under cultivation.

L. esculentum is more a cultigen than a natural species. By cultivation, selection and probably hybridization, its characters have been changed so much that its wild form is difficult to recognize. Based on certain botanical features, four sub-species are recognized: viz. *typicus, galeni, humboldtii* and *intermedium.* The cultivated tomato is a derivative of *typicus,* which includes five varieties, viz. var. *commune* Bailey (Common Tomato), var. *cerasiforme* A. Gray (Cherry Tomato), var. *grandifolium* Bailey (Large-leaved Tomato), var. *pyriforme* Alef. (Pear Tomato) and var. *validum* Bailey (Upright Tomato). Var. *cerasiforme* is considered to be the form from

I.A.R.I., New Delhi

FIG. 67. LYCOPERSICON ESCULENTUM (PUSA RUBY) —FRUITING BRANCH

which cultivated types have probably arisen as hybrids with other species (Muller, *Misc. Publ. U.S. Dep. Agric.*, No. 382, 1940, 12–15; Luckwill, 16–26).

Var. *cerasiforme* is characterized by pentamerous flowers and small, smooth, spherical, bilocular fruits, whereas the commonly cultivated tomato, now assigned to var. *commune*, has hexamerous flowers and multilocular fruits. It has been postulated that this condition has been derived by fasciation, first among the domesticated types of var. *cerasiforme* in Mexico and again by reverse mutation among forms cultivated in Europe (Jenkins, *Econ. Bot.*, 1948, **2**, 379; Luckwill, 25; Muller, loc. cit.).

Numerous types of tomatoes are grown in various countries. They are mostly evolved by pure-line selection as well as by hybridization and recommended for their adaptability and performance under local conditions. Cross-breeding between different species has been employed to yield types tolerant or resistant to heat or cold and specific diseases, and showing adaptability to various processes of utilization. In recent years, efforts are being made to exploit hybrid vigour to obtain high yields of crops. Intergeneric grafting or vegetative hybridization has also been attempted in U.S.S.R. Thus tomato has been grafted on potato, tobacco, *Solanum* spp. and tree tomato (*Cyphomandra betacea*). A graft generation obtained as a result of grafting on *Cyphomandra* has proved to be virus-resistant and capable of bearing crops for three years; it bears large fruits with high sugar content and good keeping quality. Grafting on *Solanum stramonifolium* Jacq. syn. *S. demerarense* Dem. and *S. juripeba* Rich. has yielded plants which are wilt-resistant; this method is reported to be adopted by truck gardeners in Trinidad (Singh & Pal, *Sci. & Cult.*, 1948–49, **14**, 103; *Yearb. Agric. U.S. Dep. Agric.*, 1937, 123, 176–87; Singh, *Bull. Indian Coun. agric. Res.*, No. 76; Lesley, *Econ. Bot.*, 1948, **2**, 100; Allerton, 175; Genders, 13–14; *Hort. Abstr.*, 1950, **20**, 1693; 1955, **25**, 2943; 1953, **23**, 1944; *Plant Breed. Abstr.*, 1957, **27**, 1593; Madramootoo, *Trop. Agriculture, Trin.*, 1957, **34**, 65).

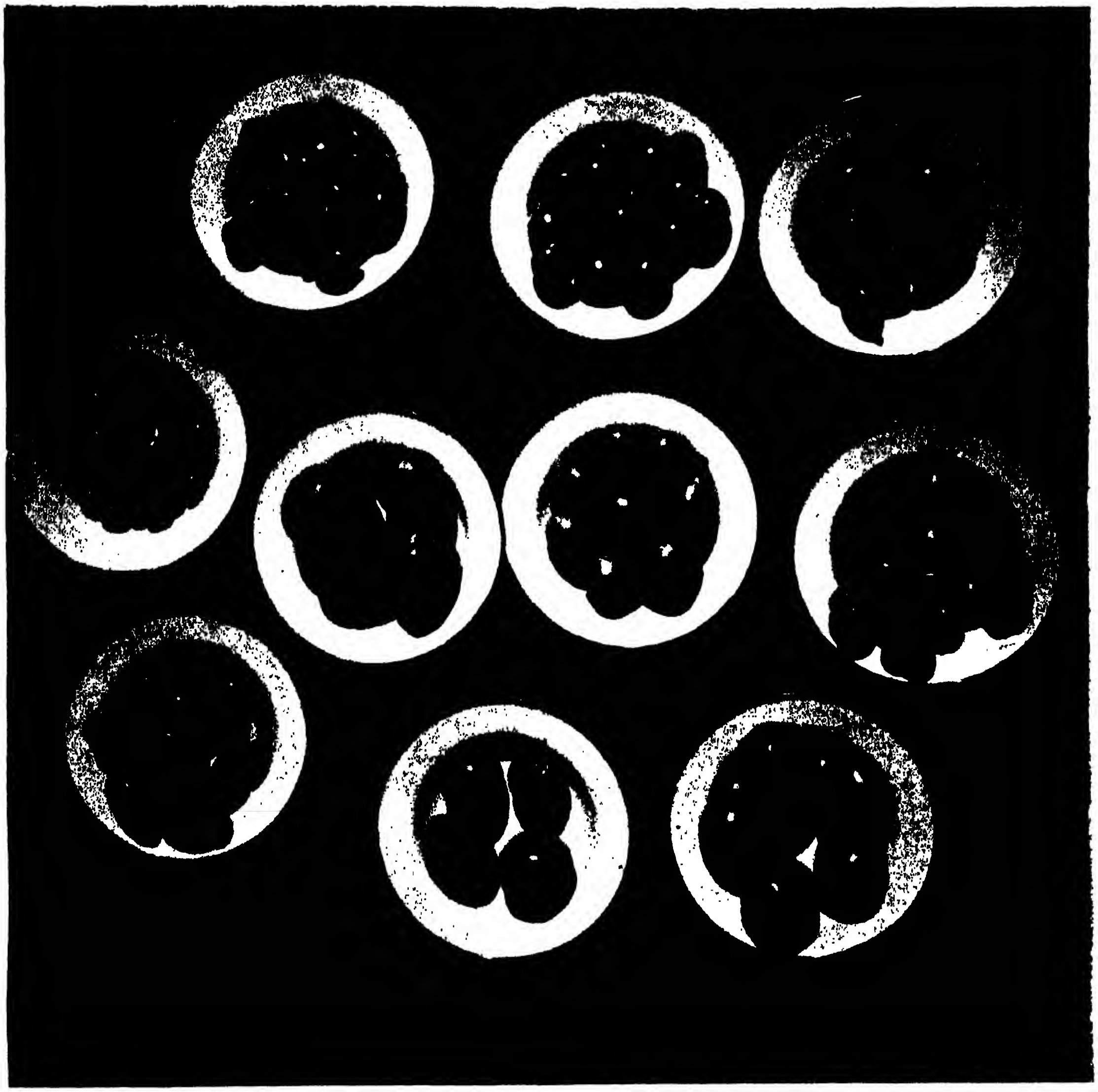
The cultivation of tomato on a commercial scale in India began towards the close of the last century. It has now become a popular vegetable and is cultivated extensively, particularly in the vicinity of large towns and cities. Exact data on the acreage and production of tomatoes in India are not available. Table 1 lists the more important types grown in India and their characteristics.

Cultivation

Climate—The tomato plant requires a warm growing season with plenty of sunshine and adequate moisture. It does not tolerate frost. It can be cultivated under irrigation in arid tropics, but hot and dry or hot and humid months are not favourable for its growth. High humidity with high temperature renders the plant susceptible to foliage diseases. For the proper development of colour in the fruit, warm sunny days and moderately cool nights are necessary [Singh & Sikka, *Indian Fmg, N.S.*, 1955–56, **5**(3), 18; Purewal, 61; Thompson & Kelly, 474].

Soil—A well-drained, light, fertile loamy soil, with a fair capacity to hold moisture is best suited for tomato. For early crops sandy loam is more suitable.

Propagation—The plant is propagated mostly by seeds, though vegetative propagation is also possible.



Indian Coun. Agric. Res., New Delhi

LYCOPERSICON ESCULENTUM — FRUITS OF DIFFERENT TYPES

TABLE 1—CHARACTERISTICS OF SOME IMPORTANT TOMATO TYPES GROWN IN INDIA*

Type	Fruit Characteristics	Agricultural Characteristics
Sioux	Fruit large (av. wt., 4 oz.), roundish, uniformly bright red, sub-acid, with large central fleshy core	Plant medium-sized, open habit; early ripening: autumn crop takes 100 days to mature and spring crop, 160 days; heavy yielding (up to 550 md./acre)
Improved Meeruti	Fruit medium-sized (av. wt., 2 oz.), flattish, slightly furrowed, bright red, acidic; suitable for stewing; good keeping quality	Semi-dwarf, erect when young, profusely branching; suitable for autumn and spring crops; hardy; suffers less from virus diseases than local types
Pusa Ruby (Sioux × Improved Meeruti)	Fruit medium-sized, uniformly red, with sub-acid flavour; good keeping quality	Early type: autumn crop takes 60 days to mature and spring crop, 120 days; high yielding (487 md./acre); less susceptible to virus than local types; tolerant to adverse weather conditions
Pusa Red Plum (Hybrid-6) (*L. esculentum* × *L. pimpinellifolium*)	Fruit small (av. wt., 0.4 oz.), rich red, sweet (up to 5% sugar) and rich in vitamin C (50-60 mg./100 g.)	Semi-climbing, suitable for autumn crop; resistant to virus; yields up to 150 md./acre; suitable for soils of medium fertility; staking of plants essential
Large Red (T-13)	Fruit medium-sized, corrugated and pressed, red, non-acidic	Mid-season type, takes 128 days to mature; medium tall, luxuriant growth; heavy yielding; fairly resistant to frost; suitable for both autumn and spring crops
Best of All (T-29)	Fruit medium-sized, round and deep red	Mid-season type, takes 121 days to mature; medium tall, moderate growth; heavy yielding
Bonny Best (T-28)	Fruit medium-sized, round or oblate, deep red, slightly acidic; cracking and scalding of fruits common	Mid-season type, takes 122 days to mature; tall, moderate growth; very heavy yielding; suitable for autumn and spring crops; poor resistance to frost and susceptible to heat; early maturing in Kerala
Marglobe	Fruit medium- or big-sized, round, bright red; considered good for canning in U.S.A.	Semi-erect, self pruning, heavy yielding; tolerant to fusarium wilt
Ponderosa	Fruit big-sized, purplish pink, fleshy with very few seeds	
Oxheart	Fruit large, heart-shaped, pinkish red, fleshy, few seeded with pleasant flavour	
King Humbert	Fruit pear-shaped, scarlet, small, fleshy	Best suited for hot season
Pritchard	Fruit globose, medium-sized, bright red	Somewhat resistant to fusarium wilt
Pearson	Fruit medium-sized, flattened globe, bright scarlet red	Tolerant to a wide range of temperatures; useful for extending period of summer crop
Prosperity	Fruit medium-sized, round, in clusters	Ripening later than Sioux; suitable for autumn crop

*Purewal, 63; Singh, *Bull. Indian Coun. agric. Res.*, No. 76, 1956; Singh & Sikka, *Indian Fmg, N.S.*, 1955-56, **5**(3), 18; Singh & Bhagchandani, ibid., 1956-57, **6**(7), 28; Nambiar, *Bull. Indian Cocon. Comm.*, 1956-57, **10**, 158; Gopalaswamiengar, 548; Pal *et al.*, *Indian J. Hort.*, 1956, **13**, 64; Singh, *Indian Fmg, N.S.*, 1953-54, **3**(3), 100; Boswell, *Yearb. Agric. U.S. Dep. Agric.*, 1937, 344-46.

Tomato seeds are small (*Sioux*, 9,600 seeds/oz.; *Improved Meeruti*, 12,800 seeds/oz.; and *Pusa Red Plum*, 13,700 seeds/oz.) and when well dried and stored in air-tight containers, they retain their viability for 3–4 years. For seed collection, the crop is carefully examined, rogue or off-type plants as well as diseased ones are pulled out and selected fruits allowed to ripen on the plant. The contents of ripe fruits are squeezed out and fermented for 2–5 days when the seeds settle down; they are dried in sun or shade and stored in air-tight containers. Seeds may also be freed from pulp by the addition of dilute hydrochloric acid or washing soda. Seeds extracted by acid treatment possess a bright colour and show consistently high germination. The yield of seeds varies with the type of tomato. Some types like *Sioux* are comparatively less seedy and yield one oz. of seeds/20 lb. of fruits, while *Pusa Red Plum* yields one ounce of seeds/5 lb. of fruits [Naik, 1958, 130; *Chem. Abstr.*, 1951, **45**, 2066; Purewal, 61–62; Singh & Sikka, *Indian Fmg, N.S.*, 1955–56, **5**(3), 18; Roy Choudhury, *Indian Hort.*, 1957–58, **2**(1), 5].

Seeds are usually sown in nursery beds or boxes and seedlings transplanted in the field; seeds may also be sown directly in the field and seedlings thinned as desired.

Seedlings raised during the hot and humid season are sometimes affected by soil-borne fungi which cause damping off or black leg. To prevent this, treatment of soil with formaldehyde (in the form of

dust or solution) or with a solution of copper sulphate, potassium permanganate or mercuric chloride is recommended; treatment with Ceresan or copper oxide is also reported to be effective [Singh & Sikka, *Indian Fmg, N.S.*, 1955-56, **5**(3), 18; Allerton, 40; Purewal, 94; Chattopadhyaya, *Sci. & Cult.*, 1951-52, **17**, 37; Singh & Srivastava, *J. Indian bot. Soc.*, 1953, **32**, 1; Gattani & Kaul, *Indian Phytopath.*, 1951, **4**, 156].

In India, tomatoes can be grown nearly throughout the year, since favourable climatic conditions are available in one part or another. In the hills, seeds are sown from about the middle of March to the middle of May or June. In the plains, three crops are raised, two early crops and a main crop; seeds are sown in June-August for the first crop, August-October for the second crop and October-November for the third crop. In Malabar, where the tomato is grown as a catch crop in young coconut plantations, seeds are sown in September and seedlings transplanted in October. One ounce of seeds gives enough seedlings to plant an acre; a higher seed rate is usually employed to offset seedling losses in the nursery and in the field. Seeds take 7-10 days to germinate and seedlings are ready for transplanting in 4-6 weeks; a slightly longer period is necessary in winter. By judicious adjustment of water supply in the nursery, seedlings are hardened to withstand the change of conditions when transplanted. Addition of potash (12%) is stated to promote hardening of seedlings and produce firmer and stiffer stems. Spraying with 10% sugar solution several days before pulling the seedlings is reported to improve the survival rate and promote the growth of plants [Naik, 1958, 130; Purewal, 61-62; Singh & Sikka, *Indian Fmg, N.S.*, 1955-56, **5**(3), 18; Nambiar, *Bull. Indian Cocon. Comm.*, 1956-57, **10**, 158; *Biol. Abstr.*, 1949, **23**, 3015; Work, 331].

Seedlings are transplanted on flat beds or on the sides of raised beds; the latter method is preferred since it prevents the lower trusses of fruits from contact with moist soil. In hilly areas, staking is done when the plants are 9-15 in. high. As a general rule, more space is allowed between rows than between individual plants in a row. Suggested spacings are 5 ft. × 2½ ft., 4 ft. × 2 ft., 3 ft. × 2 ft. and 2 ft. × 1 ft. A spacing of 4 ft. × 2 ft. is recommended for *Marglobe* crop in Bihar. Oblique planting of seedlings favours the development of a large root system with corresponding increase in yield [Singh & Sikka, *Indian Fmg, N.S.*, 1955-56, **5**(3), 18; Purewal, 62; Thompson & Kelly, 48; Roy *et al.*, *Indian J. Hort.*, 1954, **11**, 131; *Hort. Abstr.*, 1952, **22**, 603].

Manuring—Liberal manuring is necessary to ensure good yields. Farmyard manure is usually applied to the soil at the rate of 15-20 cartloads per acre, several weeks before sowing. Green manuring with crops like sannhemp (*Crotalaria juncea*), cowpea (*Vigna catjang*), dhaincha (*Sesbania aculeata*), velvet bean (*Mucuna deeringianum*) or guar (*Cyamopsis tetragonoloba*) may be substituted for farmyard manure; the application of 150 lb. of superphosphate per acre to the green manure crop before sowing and addition of 50 lb. nitrogen per acre after the crop is ploughed in, are reported to give the best results. Top dressing with 800 lb. of groundnut cake and 200 lb. of ammonium sulphate per acre, applied in two equal doses, has a beneficial effect both on yield as well as size of fruit.

'Starter' solutions, prepared by dissolving a suitable soluble fertilizer in water, may be applied at the time of planting to stimulate early growth. Boron and zinc in minute quantities have a beneficial effect on the yield as well as the carbohydrate and vitamin C contents of fruits; zinc is reported to shorten the period of maturation. Deficiency of potassium in the soil leads to the production of blotchy fruits. Excess of nitrogen favours vegetative growth but fruit-setting is affected and the fruits produced tend to be puffy [Singh & Sikka, *Indian Fmg, N.S.*, 1955-56, **5**(3), 18; Purewal, 61; Naik, 1958, 130; Thompson & Kelly, 475-77; Govindan, *Curr. Sci.*, 1950, **19**, 319; 1952, **21**, 14, 15; *Sci. & Cult.*, 1953-54, **19**, 46; *Bull. Minist. Agric., Lond.*, No. 77, 1950, 24; *Biol. Abstr.*, 1950, **24**, 3526].

Tomato requires irrigation at intervals of a week or more under dry conditions and during the frost season. Excessive moisture, however, favours vegetative growth and blossom-drop. Heavy irrigation after a prolonged dry period results in the cracking of fruits. Late irrigation renders the fruits watery [Singh & Sikka, *Indian Fmg, N.S.*, 1955-56, **5**(3), 18; Purewal, 62].

Pruning & Training—Tomato types with indeterminate habit have to be pruned to one or two stems and trained on stakes. Axillary shoots should be removed once every week leaving a few well placed lateral branches and growing tips pinched off when the plants are *c.* 6 ft. tall. The advantages claimed for pruning and training are: less injury from foliage and soil-borne diseases, larger and cleaner fruits

and earlier harvests (Percy Lancaster, *Indian Fmg*, 1940, **1**, 323; Thompson & Kelly, 481–84).

Hydroponics—Tomato lends itself to 'soilless cultivation', the plants being fed on solutions of fertilizer salts containing all the elements necessary for healthy growth. The nursery is raised in pure sand and plants are transplanted into troughs of wood, bricks, stones, asphalt mats or mud plaster provided with inlet and drainage holes and filled to a depth of 8 in. with coarse mineral aggregate, preferably a mixture of five parts of rock chippings, gravel or cinders and two parts of sand. Irrigation is provided through inlet pipes taking care to see that the growing medium is not kept too wet as this would suffocate the plants and kill them. A fertilizer mixture containing all nutrient elements in the required amounts is sprinkled over the troughs once a week or ten days, the quantity of mixture depending upon the area of the trough, and this is washed down immediately with a light spray of water. Yields as high as 24 lb. of tomatoes per plant are reported to have been obtained by this method [Douglas, 75–109; Douglas, *Gdn J., N.Y.*, 1955, **5**, 108; Loads, 154–64; Kumar & Lall, *J. sci. Res. Banaras Hindu Univ.*, 1955–56, **6**(1), 10].

Diseases & Pests—Comparatively few diseases of tomato have been recorded in India. Damping off of seedlings in the nursery is caused by one or more fungi, e.g. *Pythium aphanidermatum* (Edg.) Fitz., *P. indicum* Balakrishnan and *Phytophthora parasitica* Dastur. Control measures include soil and seed-treatment by suitable fungicides.

Fusarium wilt is common in crops transplanted during June–July. The attack begins with the oldest leaves and the entire plant is affected in course of time. The fungus is active at a temperature range of 80–90°, persists in the soil for many years and infects plants through roots. Infection is carried to clean fields by planting diseased seedlings, by drainage water, farm implements or other agency that brings soil from the infected fields. Wilted plants should be pulled out and destroyed. The only way of preventing wilt is to grow resistant varieties. Some types, like *Sioux* and *Marglobe*, are resistant to wilt.

Fruits trailing on soil may be attacked by a soil-borne fungus, *Rhizoctonia solani* Kuhn, which causes fruit rot, characterized by black circular areas on the fruit. Keeping the fruits away from the soil helps to check the spread of the disease. Other fungal diseases of tomato are: leaf spot (*Cercospora fuligera* Rolden), leaf mould (*Cladosporium fulvum* Cke.), blight [*Phytophthora infestans* (Mont.) de Bary], buck eye rot [*Phytophthora parasitica* Dastur] and soft rot (*Oospera lactus parasitica*). Spraying with Bordeaux mixture is recommended for controlling leaf spot, leaf mould, blight, fruit rot and soft rot. The application of commercial formulations of streptomycin, like Agrimycin, Phytomycin or Agristep, to foliage (100 p.p.m. in water) is said to act as a preventive to blight. A bacterial canker [*Corynebacterium michiganense* (E. F. Smith) Jensen] has been reported to infect plant tissues, fruits and seeds [Butler & Jones, 664–66; Singh & Sikka, *Indian Fmg, N.S.*, 1955–56, **5**(3), 18; Gattani & Kaul, *Indian Phytopath.*, 1951, **4**, 156; Varma, *J. Indian bot. Soc.*, 1954, **33**, 43; Doolittle, *Yearb. Agric. U.S. Dep. Agric.*, 1953, 454; Boswell, ibid., 1937, 185; Doolittle, *Phytopathology*, 1954, **44**, 409; Joshi & Saxena, *Sci. & Cult.*, 1956–57, **22**, 682; *Indian J. agric. Sci.*, 1950, **20**, 107; *Mem. Dep. Agric. Madras*, No. 36, 1954, 1182; Jain, *Sci. & Cult.*, 1955–56, **21**, 42; 1951–52, **17**, 46; *Pakist. J. Sci.*, 1956, **8**, 194].

The crop is subject to various types of virus diseases, like mosaic, necrosis, streak, leaf-roll, bunchy top and leaf curl. Some of the diseases are seed-borne and some are spread by insects, like the white fly (*Bemisia gossypiperda* M. Th.), grasshoppers and aphids, which feed on the leaves of diseased tomato or other solanaceous plants; even unrelated crops like cucumber and some perennial weeds serve as alternate hosts. The diseases are sap-transmissible and in some cases they are so infectious that simple contact with diseased plants spreads the virus. The use of seeds from virus-free plants is recommended. Seed extracted from fruits by acid treatment is preferable, as it eliminates virus contamination. Suitable measures of sanitation must be followed to prevent infection both in the seedbed and in the field by regular use of insecticides. Infected plants in the nursery should be rogued and destroyed. The best means of control consists in preventing infection in seedling plants, thus delaying the appearance of disease until the crop is well started. It has been reported that crops raised late in the season are less liable to virus infection; close planting of crop is recommended to offset the decline in yield in late plantings [Vasudeva & Lal, *Indian Fmg*, 1947, **8**, 183; Butler & Jones, 680–89; Vasudeva & Sam Raj, *Phytopathology*, 1948, **38**, 364; Chattopadhyay & Das, *Bull. bot. Soc. Beng.*, 1955, **9**, 42; Chamberlain & Fry, *N. Z. J. Sci. Technol.*, 1950–51, **32A**(2), 19;

Doolittle, *Yearb. Agric. U.S. Dep. Agric.*, 1953, 458, 462].

Tomato seedlings are sometimes attacked in the nursery by an *Epilachna* beetle. Hand-picking of egg clusters, grubs and adults as well as dusting with arsenates or 2% DDT are recommended as control measures. Tomato plants in the flowering stage are often attacked by the tobacco caterpillar (*Prodenia litura* F.) and gram caterpillar (*Heliothis obsoleta* F.). Tender parts of the plant get defoliated and caterpillars bore into ripening fruits. The caterpillars may be eliminated by hand-picking and affected fruits are removed. Spraying the crop with 0.1% DDT or 0.02% Endrin is reported to bring down infestation. Two species of fruit moths, *Ophideres materna* L. and *O. fullonica* L., attack the fruits and suck the juice. The pest can be controlled by eradicating the host plant of the larvae, *Tinospora* sp. [Singh & Sikka, *Indian Fmg, N.S.*, 1955 56, **5**(3), 18; Ramakrishna Ayyar, 279 80; Srinivasan *et al.*, *Indian Hort.*, 1958–59, **3**(3), 7; Cherian & Sundaram, *Madras agric. J.*, 1936, **24**, 360].

Fruit-setting—Cool wet weather, particularly low night temperatures, when flowers are coming to maturity, greatly diminish natural fruit-set. Hot dry winds and low humidity cause blossoms to drop. Pollination is mostly by selfing; in periods of hot weather, however, the styles elongate abnormally before flowers open and such flowers seldom set fruit.

Plant growth regulators, *e.g.* β-naphthoxy acetic acid, *o*-chlorophenoxy acetic acid, *p*-chlorophenoxy acetic acid, and γ-(indole-3)-butyric acid have been employed with some advantage to improve fruit-set. If the regulators are applied in proper concentrations at the proper stage in the development of the flower, the ovary develops parthenocarpically into a seedless fruit which is almost normal in outward appearance. Hormones increase early yield by shortening the period from blossom to fruit-setting and are most effective during the cool season when the night temperatures fall below 59–60°F. If seedless fruits are desired, flowers should be sprayed just before they open. Too early spraying may result in a decrease of fruit-set as well as a reduction in the size of fruit. Spraying 3–4 days after the flowers open increases fruit-set and fruit size, but the fruits contain more seeds than those treated before the flowers open. Under greenhouse conditions, where natural pollination is sometimes adversely affected, the necessary stimulus can be provided for fruit-setting by suitable hormone treatment. But under conditions favourable to high natural fruit-setting, hormone treatment offers little advantage, except in obtaining improved yields in the early part of the season and thus securing favourable prices; also the absence of seeds is of some advantage in the manufacture of tomato sauce. If not used in proper concentrations or in the proper way, hormones bring about undesirable effects, such as inhibition of flower buds, deformation and hollowness of fruits and deformed foliage [Thompson & Kelly, 885–86; Audus, 139–51, 386; Kerr, *Canad. J. agric. Sci.*, 1955, **35**, 300; Randhawa, *Indian J. Hort.*, 1951, **8**(4), 21; 1956, **13**(1), 20; Venkataratnam, *Indian Fmg*, 1950, **11**, 191; Singh & Kacker, *Indian J. Hort.*, 1952, **9**(4), 25].

Harvesting & Yield—Tomatoes are harvested at different stages of maturity depending upon the purpose for which they are required. Several stages of maturity are recognized: mature green fruits are those which have not begun to turn pink, while those classed as turning show some pink at the blossom end; half-ripe fruits show pink colour over most or all of the surface; ripe or red-ripe fruits are those that have developed the full colour peculiar to the type but are, at the same time, firm. Ripe fruits can profitably be picked if the market is close by. For transport to distant places, fruits at the half-ripe stage are harvested; they develop normal colour in 3–7 days. Fruits for canning or for juice extraction are harvested when they reach the ripe stage and processed soon after.

Tomatoes are harvested twice a week when the plants are about 3 months old. Fruiting may continue for a period of one or two months depending upon the soil and climatic conditions and the type grown. On an average 8,000–10,000 lb. of fruits per acre are obtained. In small scale trials with improved types, yields varying from 25,000 to 40,000 lb. per acre have been recorded. When grown in soilless units (hydroponics) in West Bengal, an average yield of 24 lb. of fruits per plant has been recorded, while under ordinary field conditions the yield ranges from 5 to 10 lb. per plant [Singh, *Indian Fmg, N.S.*, 1953–54, **3**(3), 10; Singh & Sikka, ibid., 1955–56, **5**(3), 18; Singh & Bhagchandani, ibid., 1956–57, **6**(7), 28; Singh & Pal, *Sci. & Cult.*, 1948–49, **14**, 103; Naik, 1958, 130; Douglas, *Farmer*, 1957, **8**(1), 19].

Storage & Transport—Mature green tomatoes can be kept in storage as long as 3–4 weeks at 55–60°F., while ripe tomatoes can be kept for 7–10 days at 40–45°F., and a relative humidity of 85–90%. Tomatoes should not be stored at temperatures below

40°F., since they show a tendency to break down. Fruits picked in the mature green stage can be ripened satisfactorily with the development of attractive red colour by storing at 60–70°F. (*Fruit & Vegetable Preservation Industry in India*, Cent. Fd technol. Res. Inst., Mysore, 1956, 296).

Ethylene gas is sometimes used for hastening colour development in fruits, the temperature being maintained at 55–70°F. There is little difference between fruits ripened artificially in air and in ethylene gas as regards their vitamin A, B and C contents. Vine-ripened fruits are superior in vitamin C to artificially ripened ones (Thompson & Kelly, 499; *Bull. Minist. Agric., Lond.*, No. 77, 1950, 39; Jacobs, II, 1235).

With the increasing popularity of tomato in India, considerable quantities are despatched from producing areas to markets located at considerable distances. Fruits are packed in bamboo baskets or even in earthen pots and perforated kerosene tins and transported by rail or road. Consignments have been successfully transported by rail over 1,750 miles during summer months by wrapping the fruits in paper and packing in small baskets. In U.S.A., the most widely adopted package is the wooden lug box holding 30 lb. of fruit. Corrugated board cartons to hold 10 lb. of fruit are used for local markets and 1 lb. cellophane window cartons for consumer packages. In England, the fruits are packed in specially designed 'National' tomato boxes of fibre board holding 12 lb. of fruit [Singh, *Indian Fmg, N.S.*, 1953–54, **3**(3), 10; Howard & Howard, *Agric. J. India*, 1913, **8**, 274; Thompson, 502–06; Work, 346–49].

Utilization & Composition—Fresh ripe fruits are refreshing and appetizing and are consumed raw in salads or after cooking. Unripe fruits are cooked and eaten. Large quantities of fruits are canned. Tomatoes are consumed also in the form of juice, puree, paste, ketchup, sauce, soup and powder (Girdhari Lal *et al.*, 187).

The chemical composition of tomato varies with variety and stage of maturity. The pulp constitutes 85.4% (av.) of the whole fruit and contains 6–7% total solids. Analyses of the edible portions of green and ripe fruits gave the following values: *green fruit*—moisture, 92.8; protein, 1.9; fat, 0.1; carbohydrate, 4.5; and mineral matter, 0.7%; calcium, 20 mg.; phosphorus, 40 mg.; iron, 2.4 mg.; carotene (as vitamin A), 320 i.u.; thiamine, 69 μg.; nicotinic acid, 0.4 mg.; riboflavin, 60 μg.; and ascorbic acid, 31 mg./100 g.; *ripe fruit*—moisture, 94.5; protein, 1.0; fat, 0.1; carbohydrate, 3.9; and mineral matter, 0.5%; calcium, 10 mg.; phosphorus, 20 mg.; iron, 0.1 mg.; carotene (as vitamin A), 320 i.u.; thiamine, 120 μg.; nicotinic acid, 0.4 mg.; riboflavin, 60 μg.; and ascorbic acid, 32 mg./100 g. Tomato contains folic acid, pantothenic acid, biotin, vitamin K and inhibitols which are related to vitamin E (Jacobs, II, 1234; Winton & Winton, II, 406; *Hlth Bull.*, No. 23, 1951, 40, 50; Sherman, 433; von Loesecke, 1942, 276; *Chem. Abstr.*, 1954, **48**, 7813; 1953, **47**, 1305; Lachat, 5).

The ascorbic acid content of tomato is only slightly, if at all, affected by the degree of ripeness after the fruit is mature green. Unripe fruits contain ascorbic acid in a combined form; dehydro-ascorbic acid is also present. Fruits exposed to direct sunlight contain a higher concentration of ascorbic acid than those ripening in shade. Fruits of wild varieties are richer in ascorbic acid (46–79 mg./100 g.) than those of cultivated ones (Jacobs, II, 1243; *Sci. Rep. agric. Res. Inst., N. Delhi*, 1949, 163; *Chem. Abstr.*, 1953 **47**, 8191; *Food Sci. Abstr.*, 1955, **27**, 194, 566).

Ripe tomatoes contain glucose and fructose as the principal sugars with small amounts of sucrose and a ketoheptose; raffinose has been identified in the ripe fruit. The polysaccharides present include cellulose, pectin, an araban-galactan mixture and a xylan-rich fraction. The concentration of glucose in the fruit increases with ripening; starch present in unripe fruit disappears at an early stage of ripening [Williams & Bevenue, *J. agric. Fd Chem.*, 1954, **2**, 472; Airan & Barnabas, *J. Univ. Bombay*, 1953, **22B** (34), 29; Jacobs, II, 1235].

The texture and firmness of the fruit is largely influenced by the pectic constituents. Protopectin is the predominant constituent of the green fruit. As the fruit ripens, the pectin content increases and the protopectin decreases; the transformation is particularly rapid at the later stages of ripening. Table 2

TABLE 2—PECTIC CONSTITUENTS OF TOMATO AT DIFFERENT STAGES OF RIPENING*
(As calcium pectate, dry basis)

	Pectin %	Protopectin %
Green	1.02	2.42
Yellow	2.34	2.21
Pinkish red (ripe)	3.10	1.62
Over-ripe	2.29	1.17

*Savur & Sreenivasan, *J. sci. industr. Res.*, 1946, **5B**, 41.

indicates the changes in pectin constituents of ripening tomato (Kertesz, 323 27 ; Jacobs, II, 1239).

Ripe and unripe fruits contain all the essential amino acids, except tryptophan ; in addition, cystine, tyrosine, aspartic acid, glutamic acid, serine, glycine, γ-aminobutyric acid and pipecolic acid have been identified. A globulin is also present (Airan & Barnabas, *Sci. & Cult.*, 1953–54, **19,** 201 ; Rao *et al.*, *J. sci. industr. Res.*, 1956, **15C,** 39 ; Jacobs, II, 1239).

The principal organic acid present in the tomato fruit is citric acid ; malic acid also occurs in appreciable amounts. Citric acid occurs as primary citrates and malic acid as an acid salt. Traces of acetic, formic, lactic, succinic and arabic acids are also present. Oxalic and tartaric acids have been detected in spoiled fruits. The acidity generally increases from the green to the turning stage and then decreases as the fruit ripens. Free locules are more acidic than the flesh (Thorpe, XI, 663 ; Jacobs, II, 1233–34, 1242–43 ; *Chem. Abstr.*, 1954, **48,** 8982).

Carotenoids, β-carotene and lycopene, constitute the chief colouring matters of tomato ; their concentration in the fruit varies widely with variety and the stage of ripeness. The total carotenoids increase during ripening. Lycopene is absent in green tomato and appears when the fruit just begins to turn red ; as the fruit ripens further, the lycopene content increases rapidly. The concentration of β-carotene and other carotenoids show only a slight increase with ripening. Fruits ripening naturally on the vine are richer in carotenoids than those picked green and ripened by storage. Ripening by the use of ethylene hastens lycopene formation as well as chlorophyll decomposition, but the fruits contain less β-carotene than vine-ripened fruits. Temperature and light conditions during the growth of tomato influence the development of carotenoids. Both lycopene and carotene increase in tomatoes ripened at 50–86°F. ; at higher temperatures, lycopene formation is inhibited and only carotene is formed. To attain maximum carotenoid content, the fruits should be grown under full exposure to light and allowed to mature on the vine (Sadana & Bashir Ahmad, *J. sci. industr. Res.*, 1948, **7B,** 172 ; Bahl *et al.*, *Indian J. med. Res.*, 1949, **37,** 183 ; *Chem. Abstr.*, 1955, **49,** 7772 ; *Nutr. Abstr. Rev.*, 1955, **25,** 652 ; Jacobs, II, 1238–39).

TABLE 3—COLOURING MATTERS IN GREEN, HALF-RIPE AND FULLY RIPE FRESH TOMATO*

(mg./100 g.)

	Green	Half-ripe	Fully ripe
Lycopene	0.11	0.84	7.85
Carotene	0.16	0.43	0.73
Xanthophylls	0.02	0.03	0.06
Xanthophyll ester	0.00	0.02	0.10

*Jacobs, II, 1237.

The constituent colouring matters of fresh tomato at different stages of development are given in Table 3. β-Carotene is the principal carotenoid pigment ; zeaxanthin and lutein are the main xanthophylls. In types bearing yellow or green fruit, lycopene is present only in traces ; in dark red types the concentration is as high as 300–400 μg./g. Several other colouring principles, e.g. neolycopene A, neolycopene B, prolycopene, α-, γ- and ζ-carotenes, neo-β-carotene B, neo-β-carotene U, lycoxanthine, phytofluene and neurosporene have been reported to be present. Analysis of a number of cultivated and wild types of Indian tomatoes, however, showed the presence of only lycopene, neolycopene, β-carotene, neo-β-carotene B and xanthophylls. The chlorophyll content of fresh green tomato is *c.* 3 mg./100 g. (Jacobs, II, 1237–40 ; Bahl *et al.*, loc. cit. ; Goodwin & Jamikorn, *Nature, Lond.*, 1952, **170,** 104).

The mineral constituents present in fresh ripe tomatoes are: sodium, 2.8 ; potassium, 288 ; calcium, 13.3 ; magnesium, 11.0 ; iron, 0.43 ; copper, 0.10 ; phosphorus, 21.3 ; sulphur, 10.7 ; and chlorine, 51.0 mg./100 g. ; aluminium, manganese, cobalt, zinc, boron, arsenic and iodine are reported to be present in traces. Fresh Indian tomatoes contain: sodium (35 mg./100 g.), potassium (216 mg./100 g.), copper (0.3μg./g.) and iodine (6 μg./kg.) (McCance & Widdowson, 91 ; Winton & Winton, II, 416 ; *Chem. Abstr.*, 1952, **46,** 4587 ; 1949, **43,** 9289 ; Young, *Sci. Progr.*, 1956, **44,** 21 ; Pain & Banerjee, *Indian J. med. Res.*, 1956, **44,** 749 ; Bagchi & Chowdhury, *Ann. Biochem.*, 1949, **9,** 107 ; Iodine Content of Foods, 101).

Pectin-methylesterase (pectase) occurs in high concentration in tomatoes and is accompanied by a depolymerase. Its activity increases as the fruit develops and ripens. Pectin polygalacturonase is present in ripe fruit but is absent in green fruit. As the fruit ripens, catalase and peroxidase activities decline but invertase activity increases. Oxidizing enzymes occur in higher concentrations in the skin than in the flesh and seeds of ripe and unripe tomatoes (Jacobs, II, 1241–42 ; Kertesz, 365).

Tomatoes contain a gluco-alkaloid, tomatine

($C_{50}H_{83(81)}O_{21}N$, m.p. 270°) and traces of solanine ($C_{45}H_{73}O_{15}N$, m.p. 285° decomp.); narcotine is reported to be present in unripe fruits. The tomatine content is the lowest in the pink stage of ripeness; it increases slightly in the fully ripe fruit. It is present in a relatively high concentration in the leaves of the plant (0.59–0.81 mg./100 g.); roots contain appreciable amounts. On hydrolysis, tomatine yields a steroid secondary amine, tomatidine ($C_{27}H_{45}O_2N$, m.p. 210°) and a tetrasaccharide moiety consisting of 1 mol. of xylose, 1 mol. of galactose and 2 mol. of glucose. A process for converting tomatidine into allopregnenolone has been worked out; the latter can be transformed into progesterone or testosterone. Tomatine is used as a precipitating agent for cholesterol [*Chem. Engng News*, 1951, **29**, 916; 1960, **38**(11), 37; Heilbron & Bunbury, IV, 535–36; Manske & Holmes, VII, 358; *Chem. Abstr.*, 1955, **49**, 8521; 1952, **46**, 8722, 3221; Henry, 661; Winton & Winton, II, 412; *Biol. Abstr.*, 1949, **23**, 512].

Tomato seeds—Analysis of seeds gave the following values: moisture, 8.95; protein, 27.62; fat, 24.40; lecithin, 0.56; N-free extr., 21.41; fibre, 13.60; and ash, 4.02% (Winton & Winton, II, 411).

Expressed oil from the seeds (yield 15–17%) is brown or reddish in colour with a strong odour. It has the following characteristics: sp. gr.$^{25°}$, 0.9189–0.9196; $n^{25°}$, 1.4715–1.4728; sap. val., 186.3–192.0; iod. val. (Hanus), 117.5–125.0; R.M. val., 0.1–0.3; Polenske val., 0.4–0.6; and acet. val., 10.0–20.5. It contains: saturated acids (C_{16-22}), 14.7–18.0% and unsaturated acids (mainly oleic and linoleic), 76.1–80.6%. The oil is used after refining and bleaching as salad oil and for the preparation of margarine; it is also used in soap and paint industries (Winton & Winton, II, 411; Jamieson, 243; Eckey, 736–37; Brady, 827).

Tomato seeds contain 2 globulins; albumin and glutelin are absent. Arginine is the principal amino acid present in the globulins (α-globulin, 13.97% and β-globulin, 10.65%); other amino acids present in α- and β-globulins are: cystine, 1.28 and 1.14; tryptophan, 1.15 and 1.45; lysine, 1.16 and 3.80; and histidine, 4.89 and 6.35%. The pressed cake (protein, 37%) is used as a feed for livestock and as a fertilizer (Winton & Winton, II, 411–12; Jamieson, 243).

Tomato Products

Canned tomatoes—Ripe tomatoes of medium size, regular shape, uniform red colour, solid meat and of good flavour are selected for canning. They are washed, scalded in boiling water or steam for 2–3 min., peeled and canned with or without the addition of tomato juice; common salt (1%) and sometimes a little sugar are added. Dipping in a solution of calcium chloride or addition of a calcium salt in the can aids in keeping peeled fruits firm during processing (Girdhari Lal *et al.*, 74; Kertesz, 553).

Tomato juice—Ripe tomatoes, with bright red colour and high acidity, are used for the expression of juice by the hot- or cold-break process. The former involves preliminary cooking for 3–5 min.; the extracted juice is viscous and suspended solids do not readily separate out. In the cold-break process, trimmed fruit is passed directly to the extractors; the juice obtained is thin and possesses the flavour of fresh tomato. It is homogenized to retard the separation of suspended solids; deaeration is recommended for ascorbic acid retention. Yield of juice is c. 60% (Girdhari Lal *et al.*, 187–90; Jacobs, III, 2201–02; *Brochure on Home-Scale Food Preparation Series*, Cent. Fd technol. Res. Inst., Mysore, No. 9, 1959).

Tomato juice is highly esteemed as an appetizing and nourishing beverage. It is sometimes seasoned to produce a cocktail (Tomato Juice Cocktail). Tomato Juice Powder is prepared by dehydrating the juice (Girdhari Lal *et al.*, 193; Tressler & Joslyn, 639–40, 727).

Commercial tomato juice should conform to the specifications laid down by the Government of India. It shall be a liquid product (total solids, $\nless$5%) derived from sound, fresh and fully ripe tomatoes, practically free from insect and fungal attack or any other blemish affecting the quality of fruit, and may contain finely divided insoluble solids from the flesh of tomatoes. It shall be free from pieces of skins, seeds, bits of coarse tissue and any extraneous matter. The only substances that may be added are salt ($\ngtr$1.5%), sugar, dextrose, malic acid, ascorbic acid, citric acid and permitted colours. Analysis of various brands of tomato juice from the Indian market gave the following values: sp. gr.$^{20°}$, 1.0240–1.0387; total solids (mostly sugars), 5.66–9.27%; salts (as NaCl), 0.79–1.74 g.; and acidity (as malic acid), 0.36–0.59 g./100 cc. (Girdhari Lal *et al.*, 332, 191).

Tomato ketchup (Catsup)—Tomato ketchup is prepared from ripe tomatoes of deep red colour by cooking the pulp in kettles with spices (chopped

onion and garlic, cloves, cardamom, black pepper, cumin, mace and cinnamon). Cooking is continued till the desired consistency is obtained. Vinegar, salt, sugar and sometimes pectin, are added. According to Government of India specifications, tomato ketchup shall have good flavour and shall be free from burnt or any other objectionable flavour; it shall be of good keeping quality and show no sign of fermentation: acidity (as acetic acid), $\nless$1.2%: total soluble solids, $\nless$25%. Tomato ketchup contains *c.* 475 μg./g. of lycopene; substitution of tomato solids by carrot, ash gourd, pumpkin, sweet potato, papaya or apple pulp can be detected by determining the lycopene content (Girdhari Lal *et al.*, 195–200, 334; Om Parkash *et al., Food Technol., Champaign*, 1959, **13,** 414).

Tomato soup—For preparing tomato soup, the fruit pulp is partly neutralized by adding sodium bicarbonate solution and then concentrated in a pan; spices, arrowroot and butter (or cream) are added. When the desired consistency is obtained, salt and sugar are added and the mass boiled for another two minutes. According to specifications formulated by the Government of India, tomato soup shall contain not less than 7% total soluble solids (other than added salt), it should show no sign of fermentation when incubated at 37° for 7 days. A process has been developed for drying the soup and preparing soup powder (Girdhari Lal *et al.*, 201–02, 332; Date & Bhatia, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1953 54, **3,** 19).

Tomato pomace—Tomato pomace consists of skins, pulp and crushed seeds obtained as a waste from tomato processing plants. It is dried and used chiefly as cattle feed. Analysis of dried pomace gave the following values: total dry matter, 94.7; protein, 22.6; fat, 14.5; N-free extr., 23.8; fibre, 30.5; and mineral matter, 3.3%: digestible protein, 16.0; and total digestible nutrients, 56.6%; nutritive ratio, 2.5. Tomato pomace contains appreciable amounts of thiamine, riboflavin and carotene. Feeding trials have shown that it can be used in concentrate mixture (up to 15%) for feeding dairy cows. Wet pomace forms a useful feed for pigs (Morrison, 557, 1066).

Production The total quantity of tomato products and sauces produced in India amounted to 454.47 tons in 1957 and 638.30 tons in 1958; 188 units were licenced to manufacture tomato products in 1959 (Information from Directorate of Marketing & Inspection, Govt. of India).

L. pimpinellifolium Mill. CURRANT TOMATO
Bailey, 1947, II, 1932.

A diffuse, slender-stemmed, finely puberulent herb with long inflorescences and infructescences, attaining under greenhouse conditions a length up to 1.2 m. and bearing up to 150 currant-like fruits; fruit 2-celled, spherical, 1.0–1.5 cm. diam., shiny red or orange red, edible.

The currant tomato is closely related to *L. esculentum* and is included in the sub-genus *Eulycopersicon*. It hybridizes readily with *L. esculentum*, but not with wild species of *Eriopersicon*. It is a native of Peru and Ecuador and is sometimes grown in greenhouses for its pendent fruits. Under cultivation, it withstands hot weather better than the commercial types and produces an early crop of fruits, which are non-splitting; fruits have a sub-acid flavour and are

I.A.R.I., New Delhi

FIG. 68. LYCOPERSICON PIMPINELLIFOLIUM (CURRANT TOMATO) —FRUITING BRANCH

sweeter than those of cultivated types. Hybrids of this species with *L. esculentum* yield small sized fruits which are useful for canning and bottling: one such type, *Pusa Red Plum*, has been developed in India.

The currant tomato possesses several useful characters, e.g. early maturity, high vitamin C content and bright red colour of fruit and resistance to certain diseases; certain strains are immune to fusarium wilt [*Fusarium oxysporum f. lycopersici* (Sacc.) Snyder & Hansen]. Strains of currant tomato resistant to early blight [*Alternaria solani* (E. & M.) Jones & Grout], late blight [*Phytophthora infestans* (Mont.) de Bary], leaf mold (*Cladosporium fulvum* Cke.), grey leaf spot (*Stemphylium solani* Weber), tobacco mosaic and spotted wilt are also known. It contains an antibiotic agent, tomatine, which is useful against certain fungal diseases more particularly of the skin. Currant tomato is being increasingly employed by breeders for purposes of hybridization with cultivated types [Muller, *Misc. Publ. U.S. Dep. Agric.*, No. 382, 1940, 15, 16; Luckwill, 27; Lesley, *Econ. Bot.*, 1948, **2,** 100; Pal & Singh, *Indian J. Genet.*, 1943, **3,** 115; Singh & Pal, *Sci. & Cult.*, 1948–49, **14,** 103; Doolittle, *Phytopathology*, 1954, **44,** 409; Cardon, *Chemurg. Dig.*, 1949, **8**(5), 11].

The fruits contain 9% sugar; lycopene (85.4 μg./g.), β-carotene (9.3 μg./g.) and phytofluene (2.0 μg./g.) are the principal carotenoids present. The leaves contain tomatine and rutin (*Chem. Abstr.*, 1954, **48,** 13837; Mackinney *et al.*, *Proc. nat. Acad. Sci., Wash.*, 1954, **40,** 695; Fontaine *et al.*, *Arch. Biochem.*, 1947, **15,** 89).

L. peruvianum Mill. and *L. hirsutum* Humb. & Bonpl. are two wild species of the sub-genus *Eriopersicon* which are of interest to tomato breeders, as they possess a great measure of resistance to the diseases of cultivated tomato. Under the climatic conditions obtaining at Delhi, *L. peruvianum* flowers and fruits profusely producing viable seeds; *L. hirsutum* does not set fruit, though it flowers profusely. The fruits of *L. peruvianum* have a sweetish taste not unlike that of tomato. The fruits of *L. hirsutum* contain solanine and are unpalatable and probably poisonous. Both species are usually incompatible when crossed with cultivated tomato. Successful crossing with *L. esculentum* as the female parent has been recently reported by following the method of repeated pollination with a mixture of pollen of *L. peruvianum* and *L. hirsutum* (Luckwill, 28–31, 36–38; Muller, *Misc. Publ. U.S. Dep. Agric.*, No. 382, 1940, 17–18; Doolittle, *Phytopathology*, 1954, **44,** 409; Singh & Pal, *Sci. & Cult.*, 1948–49, **14,** 103).

Two other species of the sub-genus *Eriopersicon* tried in India are *L. pissisi* Phil. and *L. glandulosum* C. H. Muller. The former is a native of the coastal districts of Peru and Chile and has been experimentally cultivated at the Indian Agricultural Research Institute, New Delhi, where it flowers and fruits well. The fruits are smaller than those of *L. peruvianum*, more mealy and not bitter; they do not change to red or yellow on ripening. *L. glandulosum* is a perennial, native of Peru bearing small globose fruits, greenish white in colour with darker stripes. The fruits have a bitter flavour, probably due to presence of solanine, and are of little economic value (Luckwill, 32–34, 38–40; Singh, *Bull. Indian Coun. agric. Res.*, No. 76, 1956, 27).

LYCOPODIUM Linn. (*Lycopodiaceae*)

A genus of evergreen herbs, commonly known as Clubmosses, found in the tropical and temperate regions of the world. About 32 species are recorded in India; some of them are epiphytic and some are ornamental.

L. cernuum Linn.

Haines, VI, 1221.

Lushai—*Kangrem.*

An erect or creeping herb found nearly throughout India, from Garhwal eastwards to Sikkim, Bhutan, Assam, Khasi and Lushai hills and further south on the hills of S. India; it occurs also in S. Andaman Islands (Chowdhury, *Trans. nat. Inst. Sci. India*, 1935–38, **1,** 194).

L. cernuum is commonly found on river banks and has been tried as a cover plant for worn-out soils in rubber plantations in Ceylon. It is cultivated as an ornamental in the Philippines. In Malaya, a decoction of the plant is used as a lotion in beri-beri and also for coughs and uneasiness in the chest. An embrocation of the ashes in vinegar is recommended for skin eruptions. Cernuine ($C_{16}H_{26}ON_2$, m.p. 106°) and small quantities of nicotine and an uncharacterized base L_{33} (m.p. 218°) have been isolated from the plant (Burkill, II, 1377; Quisumbing, 70; Marion & Manske, *Canad. J. Res.*, 1948, **26B,** 1).

L. clavatum Linn. Common Clubmoss

D.E.P., V, 100; Chittenden, III, 1219.

Lushai—*Thingribuk*; Nepal—*Nagbeli.*

A trailing or creeping herb found from Kumaon eastwards in Bengal, Sikkim, Assam, Khasi and

Lushai hills, Manipur, and in western ghats in S. India. Stems branched: branches ascending; leaves crowded, narrow, lanceolate, incurved; spikes in pairs, cylindric, stalked with ovate membranous leaves.

The common clubmoss is indigenous to Asia, Europe and N. America and is the best known species of the genus. The spores of the plant constitute the Lycopodium of commerce. They are collected chiefly in Russia and Poland during July–August by beating and shaking the plant and sifting the powder so obtained. Lycopodium is collected also in Japan, U.S.A., Canada, Germany and Switzerland. Indian supplies come mostly from the Himalayan regions; a firm in Calcutta is reported to collect 1–2 tons of lycopodium per annum (Trease, 123; U.S.D., 1955, 770).

Lycopodium is a pale yellow, very mobile powder without odour or taste. It is unctuous to the touch and readily sticks to fingers. It has a density of 1.06–1.09, but floats in water without being wetted. The spores vary in diam. from 25 to 40 μ. Each spore is a triangular pyramid with a convex base; outer surface covered with polygonal reticulations; when crushed the ruptured spores exude small drops of an yellowish fixed oil. The spores burn with a brilliant flash when blown with a flame (U.S.S.R.P., 164; U.S.D., 1955, 770; Wallis, 21).

Lycopodium powder is commonly used as dusting powder and absorbent in excoriations of skin. It is also used as a basis for medicated snuffs. It is occasionally used as a covering for pills to prevent adhesion. Formerly lycopodium was used for dyspepsia, constipation with flatulence, hepatic congestion and pustular skin eruptions. It is used in homoeopathy against disorders of the chest and urinary passage and against rheumatism, cramps and varices (U.S.D., 1955, 771; Quisumbing, 71; Nadkarni, I, 758; Steinmetz, II, 284).

Lycopodium powder is often employed in fireworks and flashlight powders. It is used as a dusting powder for sand moulds for fine castings (Brady, 790).

Lycopodium is often adulterated with pollen of *Pinus* spp., *Typha latifolia* Linn., etc. or with roasted and coloured starches, dextrin, sulphur or inorganic salts, all of which can be readily detected under the microscope (Trease, 124; U.S.D., 1955, 771).

Lycopodium contains a fatty oil (40–50%), a complex high polymeric carbohydrate sporonin, $C_{30}H_{12}O_{27}$ (20–45%), sucrose, a protamine, hydrocaffeic acid and alkaloids (0.12%) of which lycopodine is the major constituent. The oil can be extracted by triturating the material with fine sand or pumice stone and extracting with ether. It is green to bright yellow in colour and has the following characteristics: $d_{4^\circ}^{20^\circ}$, 0.9286; $n_D^{20^\circ}$, 1.4730; iod. val. (Hanus), 90.9; and sap. val., 194.8; it maintains its liquidity even at the low temperature of 5°F. The oil contains mainly oleic acid (55–60%) and 9-hexadecenoic acid (30–35%); linoleic, myristic, palmitic and 9, 10-dihydroxy stearic acids are present. Lycopodium protamine resembles fish sperm protamine; it contains arginine, valine, proline, alanine and histidine (Hoppe, 542; U.S.D., 1955, 770; Schindler, 136; *Chem. Abstr.*, 1955, **49**, 14923; Riebsomer & Johnson, *J. Amer. chem. Soc.*, 1933, **55**, 3352).

Lycopodine ($C_{16}H_{25}ON$, m.p. 115–16°), clavatine ($C_{16}H_{25}O_2N$, m.p. 212–13°) and clavatoxine ($C_{17}H_{27}O_2N$, m.p. 185–86°) are the alkaloids identified in *L. clavatum* of European origin. American specimens contain lycopodine, nicotine and the unidentified bases L_{13} ($C_{16}H_{25}ON$, m.p. 130°), L_{18} ($C_{11}H_{19}ON$) and L_{19} (m.p. 231°); clavatine and clavatoxine are reported to be absent; it has been suggested that European and American plants are specifically or varietally different. A variety of actions such as pressor effects, stimulation and contraction of the uterus, and paralysis are attributed to lycopodium alkaloids, but none of them has been found useful in medicine. The alkaloids are mildly toxic. *L. clavatum* has been employed in various countries as an antipyretic. Aqueous extracts are reported to be effective against fever induced in rabbits by subcutaneous injection of hay infusion. Lycopodine has no curative action on malaria in ducklings (Manske & Holmes, V, 295–99; Henry, 752–55).

L. annotinum Linn., *L. complanatum* Linn. and *L. selago* Linn. are among the other species of *Lycopodium* occurring in India. The spores of these plants are collected in some countries for use as lycopodium powder. Several alkaloids, annotinine ($C_{16}H_{21}O_3N$, m.p. 232°), complanatine ($C_{18}H_{31}ON$, m.p. 169°), and α-obscurine ($C_{17}H_{26}ON_2$, m.p. 283–84°) among them, have been isolated from these species and from *L. lucidulum* Michx. and *L. obscurum* Linn. which are also found in India (Gathercoal & Wirth, 253; Manske & Holmes, V, 295–99).

LYCOPUS Linn. (*Labiatae*)

A genus of perennial herbs, often growing in marshes, distributed in north temperate regions and in Australia. One species occurs in India.

L. europaeus Linn. GIPSYWORT

D.E.P., V, 101 ; Fl. Br. Ind., IV, 648 ; Mukerjee, *Rec. bot. Surv. India,* 1940, **14**(1), 102 ; Kirt. & Basu, Pl. 758A.

KASHMIR & PUNJAB—*Jalnim, gandamgundu.*

A herb, 30-100 cm. in height, with a creeping or stoloniferous rootstock found in Punjab and Kashmir up to an altitude of 2,100 m. Leaves lanceolate or elliptic-oblong, sometimes pinnatifid ; flowers in crowded verticillasters, small, white or bluish, dotted with purple. Var. *exaltata* Hook. f. is a stouter plant with more deeply pinnatifid leaves, occurring in the same areas. It is not, however, differentiated from the type in medicinal use.

The herb is used as a cooling drug in Punjab and is reported to be sold in bazaars ; leaves are used as a poultice to cleanse wounds. The drug was formerly used in America as a mild narcotic and astringent, and in Europe, as a substitute for quinine. Clinical trials have shown that extracts of the plant are useful in the treatment of hyperthyreosis and similar diseases ; they inhibit the action of thyrotropic hormone and the thyroxine output of thyroid (Kirt. & Basu, III, 1984 ; U.S.D., 1947, 1509 ; *Chem. Abstr.*, 1955, **49,** 16234 ; Caius, *J. Bombay nat. Hist. Soc.*, 1940-41, **42,** 398).

The plant contains a bitter resin (lycopin), a volatile oil and malic acid. The fruit yields a dye which imparts a green colour to mordanted wool (Wehmer, II, 1078 ; Perkin & Everest, 634).

LYCORIS Herb. (*Amaryllidaceae*)

Bailey, 1947, II, 1934.

A genus of attractive bulbous herbs distributed in Asia, chiefly in China and Japan. Some of the species are cultivated for ornament. Two species are grown in Indian gardens.

L. radiata Herb. is propagated by bulbs taken after the blooming period. It bears large crimson flowers in August–September (Firminger, 331).

The bulbs of *L. radiata* contain at least nine phenolic alkaloids of which lycorine ($C_{16}H_{17}O_4N$, m.p. 275° decomp.) is of some importance. It is not highly toxic but in large doses, it causes vomiting and diarrhoea. *Lycoris* alkaloids are reported to be used as expectorant and febrifuge ; dihydrolycorine is used as a substitute for emetine in amoebic dysentery. The starchy residue left after the extraction of alkaloids may be saccharified by digestion with acid and fermented into alcohol. In China, the globose bulbs of the plants are made into a plaster and applied to burns and scalds (Henry, 406-07, 411 ; Manske & Holmes, II, 332 ; *Chem. Abstr.*, 1951, **45,** 3565 ; 1950, **44,** 6574 ; Cheo, *Bot. Bull. Acad. sinica,* 1947, **1,** 298).

L. aurea Herb. is a related species bearing golden yellow flowers. The bulbs of this species are used in China in applications for burns (Cheo, loc. cit.).

LYGODIUM Sw. (*Schizaeaceae*).

A genus of climbing ferns distributed in tropical and sub-tropical regions. Four species are recorded in India.

L. circinnatum (Burm. f.) Sw.

Beddome, Indian Ferns, 455, Fig. 281 ; Fl. Malesiana, Ser. II, **1**(1), 59.

A handsome climbing fern with short creeping rhizome and fronds several metres long, found nearly throughout India, up to an elevation of 600 m.

The stipes of this plant are reported to be used, in Indonesia, in external applications for wounds ; the stems are used for plaiting (Brown, 1941, I, 38 ; Burkill, II, 1378).

L. flexuosum (Linn.) Sw.

Beddome, Indian Ferns, 457, Fig. 283 ; Blatter & d'Almeida, 195, Pl. XIV ; Fl. Malesiana, Ser. II, **1**(1), 53.

BENG.—*Bhut-raj ;* MAL.—*Vallipanna.*

SANTAL *Nanjom rehet ;* BIHAR *Kalazha ;* LUSHAI —*Dawnzimpui.*

A climbing or scrambling fern with glabrous, pinnately lobed leaves found nearly throughout India up to an elevation of 1,500 m. in the Himalayas.

The plant is used as an expectorant. Fresh roots are used in external applications for rheumatism, sprains, scabies, eczema and cut wounds ; they are reported to be particularly useful for carbuncles. Stems may be used for tying rice sheaves (Kirt. & Basu, IV, 2749 ; Burkill, II, 1378).

L. japonicum (Thunb.) Sw.

Beddome, Indian Ferns, 457 ; Blatter & d'Almeida, 196 ; Pl. XIV ; Fl. Malesiana, Ser. II, **1**(1), 51.

A handsome climber resembling *L. flexuosum* found from Kashmir eastwards to Lushai hills, rarely in western ghats, up to an elevation of 2,000 m.

The plant is used as an expectorant. In China, a decoction of vegetative parts and spores is used as diuretic or cathartic (Kirt. & Basu, IV, 2749; Cheo, *Bot. Bull. Acad. sinica*, 1947, **1**, 299).

L. microphyllum (Cav.) R. Br. syn. *L. scandens* Sw.

Beddome, Indian Ferns, 455, Fig. 282; Blatter & d'Almeida, 195, Pl. XIV; Fl. Malesiana, Ser. II, **1**(1), 47.

MAL.—*Curalvallipanna*.

A slender graceful fern with pinnate fronds, many feet long, found in Bengal, Bihar, Orissa, Bombay and S. India up to 900 m. in the hills. It is also cultivated in gardens to cover pillars and bowers (Gopalaswamiengar, 384).

The young leaves are eaten in Java. A decoction of the leaves is given in dysentery; it also enters into many lotions. Leaves are applied in the form of poultices for skin diseases and swellings. Old stems which become tough are used for binding, basket making and plaiting (Quisumbing, 57–58; Burkill, II, 1378–79).

Lynxes — *see* **Tiger and Other Cats**

LYONIA Nutt. (*Ericaceae*)

A genus of shrubs and trees distributed from Himalayas to East Asia and in North America. Three species are found in India.

L. ovalifolia (Wall.) Drude syn. *Pieris ovalifolia* D. Don

D.E.P., VI (1), 229; Fl. Br. Ind., III, 460.

PUNJAB & U.P. HILLS—*Ayar, angyar, ailan*; NEPAL—*Angeri*; LEPCHA—*Kangshior, angeri*; BHUTIA—*Piazay*; KHASI—*Diengla samiang, jarahap*; LUSHAI—*Tlangham*.

A deciduous shrub or a small tree, up to 12 m. in height, found throughout the Himalayas between 600 and 3,900 m. and in the hills of Assam between 900 and 1,800 m.; it is cultivated as an ornamental tree in Nilgiris. Bark reddish brown, deeply furrowed, exfoliating in narrow strips; leaves ovate or elliptic-oblong, coriaceous; flowers in racemes, usually white, fragrant; capsule globose; seeds small.

L. ovalifolia is considered useful for covering hill slopes and as a nurse to deodar in western Himalayas. It coppices well and is fire-resistant. The rate of growth of the tree is reported to be 12–18 rings per inch of radius in western Himalayas (annual girth increment, 0.35–0.52 in.) and *c.* 6 rings per inch of radius in eastern Himalayas (annual girth increment, 1.05 in.). The tree is subject to attack by the rot causing organisms, *Fomes conchatus* (Pers.) Fr. and *Ganoderma applanatum* (Pers.) Pat. (Troup, II, 636; Khan, *Pakist. J. Sci.*, 1952, **4**, 65).

The wood (wt., 41 lb./cu. ft.) is light reddish brown, even-grained and moderately hard. It warps and shrinks during seasoning, is not durable, but cuts well: well seasoned stock is suitable for turnery. It does not burn well and the smoke is said to cause inflammation of eyes and face. The wood yields 0.51% ash rich in soluble potassium salts (Gamble, 431–32; Mata Prasad & Dange, *Indian For. Leafl.*, No. 95, 1947, 14).

An infusion of young leaves and buds is used as an application for skin diseases. The leaves contain a toxic substance, andromedotoxin, and are insecticidal. They are poisonous to goats and cattle, and cause cerebral symptoms. The honey from the flowers is also reported to be poisonous (Kirt. & Basu, II, 1459; Chopra *et al.*, 607).

L. villosa (Hook. f.) Hand.-Mazz. syn. *Pieris villosa* Hook. f. (NEPAL—*Lekh angeri*) is a small tree closely related to *L. ovalifolia* found in Himalayas from Garhwal to Sikkim at 3,000–3,900 m. It is reported to be poisonous to cattle (Cowan & Cowan, 81).

LYSIDICE Hance (*Leguminosae*)

Burkill, II, 1379; Macmillan, 86, Fig.

A monotypic genus of trees, native of southern China and Tongking. *L. rhodostegia* Hance, which attains a height of 18 m. in its native habitat, is reported to be cultivated in Indian gardens for its attractive panicles of fragrant, rose-purple flowers. The wood of this tree is not durable but used for temporary articles, like barrels, in Tongking. The seeds are edible (Gopalaswamiengar, 232).

LYSIMACHIA Linn. (*Primulaceae*)

D.E.P., V, 101; Fl. Br. Ind., III, 501.

A genus of herbs distributed in temperate regions and mountains of the tropics. About 14 species are found in India.

L. candida Lindl. syn. *L. obovata* Hook. f. (Fl. Br. Ind.) is a small slender herb, up to 50 cm. in height, found in the sub-Himalayan tracts of Uttar Pradesh, hilly parts of Bihar, Manipur and Nilgiris. The herb is reported to be eaten as a vegetable, along with fish, in Manipur.

A number of *Lysimachia* spp. are grown for ornament in temperate climates. *L. leschenaultii* Duby is a pretty tufted perennial with pink flowers, found in western ghats. It is suitable for the rockery (Chittenden, III, 1223; Firminger, 467).

M

Maba — *see* **Diospyros**

Mabuya — *see* **Lizards**

MACADAMIA F. Muell. (*Proteaceae*)

Fl. Malesiana, Ser. I, **5** (2), 194, Fig. 21.

A small genus of trees and shrubs distributed in Australia, New Caledonia and Celebes. *M. ternifolia* F. Muell., the source of Macadamia Nut, Queensland Nut or Australian Nut of commerce, has been introduced in India and grown on a small scale.

M. ternifolia is a handsome evergreen tree, up to 18 m. in height, often several-stemmed, reported to be cultivated in gardens in Nilgiris in Madras State and in Mysore and Uttar Pradesh. Leaves mostly in whorls of 3, oblong to oblanceolate; flowers cream or white; fruit globose, green, *c.* 2.5 cm. diam., splitting on one side; seed 1, rarely 2, globular or semi-globose, with a smooth, hard, thick testa [Krumbiegel, 64; Krishnamurthi, 217; Singh, *Gardening*, 1956–59, **1** (5), 26].

The tree is cultivated for its seeds, commonly called nuts, the kernels of which are highly esteemed as dessert; the nuts have attained considerable commercial importance in Hawaii Islands. The tree has a handsome symmetrical appearance, dark glossy foliage and drooping racemes; it is valued for avenues, parks and landscape work. It is hardy and resistant to drought and mild frost. Propagation may be done by nursery-raised seedlings; grafting is recommended to obtain uniformly sized nuts of good quality. Both thin-shelled and thick-shelled varieties are known. Extension of the cultivation of the tree in Nilgiris has been recommended; it is also likely to do well in sub-Himalayan tracts (Bailey, 1947, II, 1939; Howes, 1948, 68–73; Hamilton & Storey, *Econ. Bot.*, 1956, **10**, 92; Krishnamurthi, 217; Parker, 431).

The seed kernels have a delicious sweetish taste; they are pleasantly crisp and resemble hazel nuts and almonds in flavour and consistency. They are eaten raw or roasted; they are also used in confectionery. Analysis of the kernels gave the following values: moisture, 3.1; protein, 8.7; fat, 71.4; total carbohydrates, 15.1; fibre, 2.5; sugars, 2.7; and ash, 1.7%. The kernels are a good source of vitamin B_1 (486 μg./100 g.) (Hamilton & Storey, loc. cit.; Howes, 1948, 69–70; Jacobs, II, 1558; *Chem. Abstr.*, 1944, **38**, 1578).

The kernels yield a light yellow oil with mild nutty flavour and the following characteristics: solidification pt., $-12°$; n_D^{40}, 1.460–1.461; iod. val., 74–76; sap. val., 193–197; and unsapon. matter, 0.1–0.3%. The component fatty acids of the oil are: myristic, 1.6; palmitic, 8.0; stearic, 3.3; arachidic, 2.2; behenic, 0.8; hexadecenoic, 20.4; oleic, 59.3; linoleic, 2.2; and eicosenoic, 2.2%. The oil resembles olive oil and may be used as salad oil and also for high grade soaps and medicinal purposes (Eckey, 391; Howes, 1948, 69–70).

The wood is red, strong, hard and close-grained. It takes a good polish and is suitable for turning, cabinet and veneer work. The young leaves of the plant and outer covering of immature nuts are cyanogenetic (Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 136).

MACARANGA Thouars (*Euphorbiaceae*)

A genus of trees or shrubs distributed in the tropical and sub-tropical regions of the Old World. About 12 species are found in India.

M. denticulata Muell. Arg.

D.E.P., V, 103; Fl. Br. Ind., V, 446.

BENG.—*Burna, jagura.*

NEPAL—*Mallata*; LEPCHA—*Numro-kung*; ASSAM—*Jaglo, moralia.*

A moderate-sized evergreen tree, *c.* 18 m. in height and 1.2 m. in girth, found in eastern Himalayas, Assam, Bengal, Bihar and Orissa, up to an altitude of 1,500 m. Bark greyish brown; leaves peltate, broadly ovate; flowers in panicles, unisexual; capsules blackish.

The tree thrives in a warm moist climate and does not tolerate frost or drought. Under favourable conditions it springs up gregariously on abandoned forest clearings and fire-protected savannah lands. It often tends to branch low forming an umbrella-like canopy. It kills out the grass making way for shade-bearing trees and is a useful natural afforesting agent. The tree can be easily raised by seeds in the rainy season. It makes rapid growth, attaining a height of c. 12 m. in 10 years (Troup, III, 848–49; Bor, 182).

The wood (wt., 33 lb./cu. ft.) is reddish brown, moderately hard and pretty grained. It is used for fencing and temporary huts; it is reported to be suitable for tea boxes and cabinet work (Gamble, 621; Fl. Assam, IV, 218).

The tree yields a red gum kino containing 10–15% tannin and 60–70% gum. Bark and leaves contain respectively 19% and 9% tannin. A decoction of the plant is used as a cleansing agent for wounds in Malaya. Leaves are eaten by buffaloes (Wehmer, II, 682; Khan, *Pakist. J. For.*, 1956, **6,** 78; Burkill, II, 1382; Fl. Assam, IV, 218).

M. indica Wight

D.E.P., V, 103; Fl. Br. Ind., V, 446; Fyson, II, Fig. 469.

TAM.—*Uttathamarei;* MAL.—*Uppila, puthatamara.*

KUMAON—*Ramalo;* NEPAL—*Malata;* ASSAM—*Jaglo.*

A small evergeen tree found in the outer Himalayas from Kumaon eastwards at altitudes of 900–1,500 m., Assam, Bengal, Bihar and the western ghats of South India; it is also common in Andaman Islands. Bark smooth, grey; leaves peltate; flowers in panicles, unisexual; capsules small, globose.

The tree grows rapidly (mean annual girth increment, 2.09 in.). The wood is greyish red and soft; it is suitable for fencing, huts and tea boxes (Troup, III, 847; Gamble, 621).

The bark exudes a gum kino similar to that obtained from *M. peltata* (q.v.). Analysis of the kino from South Kanara gave the following values: moisture, 16.5; tannin, 6.65; gum, 70.95; and ash, 2.35% (Hooper, *Agric. Ledger*, 1900, 69).

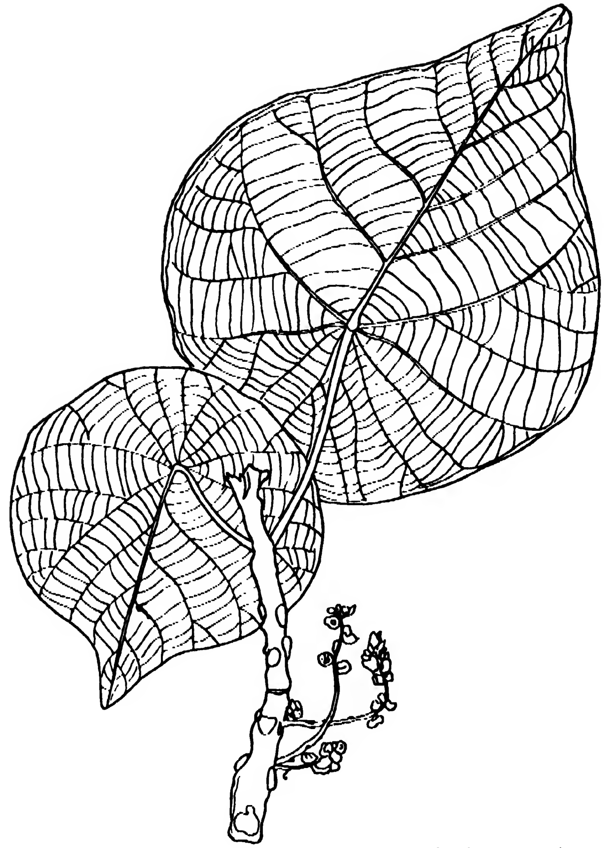
M. peltata Muell. Arg. syn. *M. roxburghii* Wight

D.E.P., V, 103; Fl. Br. Ind., V, 448; Kirt. & Basu, Pl. 877.

MAR.—*Chanda, chandwar;* TEL.—*Boddi, kondajaphara, kondatamara;* TAM.—*Vattakanni, vattathamarei;* KAN.—*Chandakanne;* MAL.—*Uppila, vatta;* ORIYA—*Piania, gondaguria.*

A small to middle-sized tree found in Bengal, Bihar, Orissa and the Deccan Peninsula, mostly in the hills. Bark dark grey; leaves peltate, ovate or orbicular; flowers in heads or panicles, unisexual; capsules globose, hairy, glandular.

The tree reproduces freely by seeds which germinate at the commencement of monsoons. It comes up plentifully in old clearings, makes rapid growth and produces large crowded leaves which are not eaten by cattle. It stands drastic pruning and puts forth flushing growth in 2–3 months. The loppings are applied as green manure to paddy fields in the west coast. It is also useful in coffee plantations for shade. The leaves are rich in nitrogen and potash: they contain: water, 60.17; N, 1.3; potassium (K_2O), 0.66; and phosphorus (P_2O_5), 0.18% (Ayyar & Mudaliar, *Madras agric. J.*, 1948, **35,** 3; Troup, III, 847; Burkill, II, 1382; *Rep. Dep. Agric. Travancore,* 1914–15, 3).



Blatter Herbarium, Bombay

FIG. 69. MACARANGA PELTATA—FLOWERING BRANCH

A reddish gum kino exudes from the cut branches, bases of petioles, young shoots and fruits. It is partly soluble in water and is available in the form of hard tears or agglutinated masses with a shiny lustre and little or no taste. A sample of kino from South Malabar contained: moisture, 17.1; tannin, 15.0; gum (mostly pararabin), 63.4; and ash, 2.1%. It is used for sizing paper and for taking impressions of leaves, coins, medallions, etc; it is used also as a substitute for gum arabic. A paste of the kino is used as an application for venereal sores; a decoction of

leaves and bark is used as a wash for ulcers. The bark contains c. 18% tannin and the leaves, 9%. The fruit is eaten in times of scarcity (Hooper, loc. cit.; Bourdillon, 308; Kirt. & Basu, III, 2271; Rama Rao, 372; Badhwar *et al., Indian For. Leafl.*, No. 72, 1944, 11).

The wood of *M. peltata* (wt., 27 lb./cu. ft.) is pale brown with a mottled appearance and is reported to be suitable for matches and paper pulp (Bourdillon, 308; *Indian For.*, 1952, **78,** 283; Rama Rao, 372).

M. pustulata King ex Hook. f.

Fl. Br. Ind., V, 445.

NEPAL—*Chilley mallata;* LEPCHA—*Numro.*

A small or moderate-sized evergreen tree found in the Himalayas from Kumaon eastwards at altitudes of 600–1,800 m. Bark grey, smooth; leaves orbicular or ovate; flowers in panicles, unisexual; capsules oblong, 2-lobed.

The tree regenerates abundantly on landslips, open ground and in young plantations. Artificial reproduction may be done by nursery-raised seedlings. The growth is fast, trees attaining a height of c. 12 m. with a girth of 0.9 m. in 10 years. The tree acts as a nurse to walnut, toon and chestnut. It, however, dies early as the wood decays easily (Gamble, 621; Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 137).

The wood (wt., 29 lb./cu. ft.) is greyish red and soft, and is suitable for fencing, huts and tea boxes (Gamble, 621).

M. tanaria Muell. Arg.

Fl. Br. Ind., V, 447.

A small tree commonly found in the Andaman Islands. Leaves large, ovate-acuminate; flowers in panicles or racemes, unisexual; capsules of the size of a pea, clothed with wax glands.

Gum kino obtained by tapping the tree is used in Java and Philippines as a glue for fastening together parts of musical instruments, like guitars and violins. The bark contains 2.1% tannin: it is used for toughening fishing nets. A decoction of the bark is given in dysentery and that of the root in fever and haemoptysis. Pounded leaves are used in poultices for wounds (Burkill, II, 1384–85; Brown, 1941, II, 318; Baens *et al., Philipp. J. Sci.*, 1934, **55,** 179).

The bark, mature leaves after shedding, and sometimes the fruits are used in the Philippines in the production of a popular fermented drink from sugarcane juice. The leaves stimulate the fermentation of cane molasses by yeast; thus addition of air-dried leaves (1.2 g./l. of molasses solution) increased alcohol yield by c. 11%. The ash constituents present in the leaves are: calcium (CaO), 0.87; phosphorus (P_2O_5), 0.21; silica, 7.62; iron and aluminium (as $Fe_2O_3 + Al_2O_3$), 0.06% (Brown, 1941, II, 318; *Chem. Abstr.*, 1939, **33,** 307).

The wood is white, tough and light. Analysis of the wood gave the following values: hot water sol., 6.27; alkali sol., 14.66; ether extr., 0.22; alcohol extr., 2.60; N, 0.40; ash, 0.93; lignin, 32.06; cellulose, 50.02 (ash content, 0.38): and α-cellulose, 39.77%. The wood is used for making temporary ladders by pepper growers in Sumatra and for diving goggles in Philippines. The bark is used for making food-containers (Burkill, II, 1384–85; West *et al., Philipp. J. Sci.*, 1933, **52,** 213; Fox, ibid., 1952, **81,** 280).

M. populifolia Muell. Arg. is a small evergreen tree found in the Andaman Islands. The wood is pale brown and moderately hard; it is reported to be more useful than most other *Macaranga* woods. Roots and leaves of the tree are used for malaria and dropsy in Malaya (Burkill, II, 1383–84).

Mace — *see* **Myristica**

Mace, Reed — *see* **Typha**

*MACHILUS Nees (*Lauraceae*)

A genus of evergreen trees distributed from India to Japan and the Philippines. About 18 species are found in India.

M. bombycina King ex Hook. f.

Fl. Br. Ind., V, 861.

ASSAM—*Som.*

A moderate-sized tree with spreading branches found in the lower Himalayas from Almora eastwards; it is also cultivated. Bark grey, covered with warty excrescences; leaves lanceolate, very variable, coriaceous, pubescent beneath; flowers in panicles; fruits globose.

This species is considered to be a cultivated form of *M. gamblei* or *M. kurzii*. It regenerates freely by seed and comes up gregariously in moist low-lying places. It grows in almost all soils and situations in Assam and is common in Bengal Duars. It coppices well.

M. bombycina is one of the principal trees on which *muga* silkworm is raised in Assam. It is also lopped for fodder. The wood is greyish brown, heavy

* Kostermans (*J. sci. Res. Indonesia*, 1952, **1,** 116) has proposed that this genus be made a synonym of *Persea* Mill.

(wt., 43 lb./cu. ft.) and tough: it is used for tea boxes (Troup, III, 788; Gamble, 567; Laurie, *Indian For. Leafl.*, No. 82, 1945, 9).

M. gamblei King ex Hook. f.

Fl. Br. Ind., V, 138, 860.

Beng.—*Kawla.*

Punjab—*Kharamb*; Garhwal & Nepal—*Kawla*; Lepcha—*Rohun kung*; Assam—*Mojli.*

A moderate-sized tree found in outer Himalayas, the sub-Himalayan tract from Chamba eastwards and in Assam up to an altitude of 1,500 m.; it usually occurs in moist and swampy places along streams and ravines. Bark greyish, rough; leaves obovate-oblong, very variable, thinly coriaceous; flowers in panicles, yellowish green; fruits globose, black.

The tree is lopped for fodder. The wood is pale yellowish grey when first exposed, ageing to reddish brown, sometimes with darker streaks; heartwood not distinct. It is rather lustrous, straight-grained, medium-fine- and even-textured, smooth, moderately hard and light (sp. gr., 0.51; wt., 33 lb./cu. ft.). It seasons well and is not very liable to end splitting or surface cracking. It is durable under cover; graveyard tests show an average durability of 20 months. The heartwood is very refractory to treatment; side and end penetration is practically nil. The timber presents no difficulty to sawing and works to a smooth shiny surface. It is used for tea boxes and packing cases; it is considered suitable for furniture, turnery and toys (Laurie, *Indian For. Leafl.*, No. 82, 1945, 9; Pearson & Brown, II, 843–45; Purnshotham *et al.*, *Indian For.*, 1953, **79**, 49; IS: 399, 1952, 14, 16, 17).

M. gammieana King ex Hook. f.

Fl. Br. Ind., V, 137, 860.

Nepal—*Seto, chipli kawla, lali, jagrikat*; Lepcha—*Rohun kung, phamlet.*

Trade—*Machilus.*

A tree, c. 18 m. in height with a fairly straight bole, found in Sikkim and Darjeeling at altitudes of 1,500–2,400 m. Bark dark brown; leaves lanceolate, variable; flowers in panicles; fruits globose.

The tree reproduces well from seeds and grows moderately fast. It is lopped for fodder. The wood is pale yellow or roseate grey when first exposed, ageing to pinkish grey, passing over into pinkish brown towards the centre, occasionally with darker streaks, lustrous, smooth, straight-grained, and fine- and even-textured. It is moderately strong, hard, light (sp. gr., 0.54; wt., 35 lb./cu. ft.) and durable. It seasons well and should be thoroughly dried in planks or scantlings before use. When cut in the quarter it presents a rather attractive appearance. It is an important building timber in Darjeeling; it is also used for tea boxes (Laurie, *Indian For. Leafl.*, No. 82, 1945, 9; Gamble, 566; Pearson & Brown, II, 841–43).

M. macrantha Nees

D.E.P., V, 104; Fl. Br. Ind., V, 140, 861.

Tam.—*Kolla mavu*; Kan.—*Gulmavu, chittutandrimara*; Mal.—*Uravu.*

Bombay—*Golum, kurma, bobarsa, pishia, pisara.*

Trade—*Machilus.*

A large tree, up to 27 m. in height and 3 m. in girth, with a cylindrical bole up to 7.5 m. long, found in Bihar and the Deccan Peninsula up to an altitude of 2,100 m. Bark pale brown with darker spots, rough; leaves variable, oblong to elliptic-lanceolate, coriaceous; flowers in panicles, yellow; fruits depressed globose, dark green, dotted with white.

The tree is a shade-bearer. It can be raised by putting out entire transplants or stumps under a top canopy soon after the break of monsoon. Its enlarged parenchyma and ray cells function as secretory organs and contain a pale lemon-coloured oil.

The wood is light orange brown when first exposed, ageing to light reddish brown or brown; heartwood not distinct; it is lustrous, smooth, interlocked-grained, medium- and even-textured, moderately hard and light (sp. gr., 0.52; wt., 33 lb./cu.ft.). It seasons well without cracking or splitting. Green conversion and seasoning of planks and scantlings in water is recommended. In South Kanara, the logs are seasoned in water before hollowing them out for dug-outs. The wood is durable: graveyard tests gave an average life of 10–15 years. It saws and machines well, but the finish is rather rough. It splits while chamfering but not during nailing (Pearson & Brown, II, 845–47; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 54; IS: 399, 1952, 25; Purushotham *et al.*, *Indian For.*, 1953, **79**, 49; Rehman *et al.*, ibid., 1954, **80**, 626).

The data for the comparative suitability of machilus timber, expressed as percentages of the same properties of teak, are: wt., 75; strength as a beam, 60; stiffness as a beam, 65; suitability as a post, 60; shock-resisting ability, 70; retention of shape, 75; shear, 80; and hardness, 55. The timber is used in house building as planks, rafters, scant-

lings, flooring and ceiling boards. It is also used for boats and dug-outs. It is suitable for commercial and tea chest plywood, dadoes, cabinet panels, slate frames and matches; it may be used for railway sleepers after treatment. It satisfies specification tests for unstressed parts of aircrafts (Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 54, Sheet No. 13; Pearson & Brown, II, 847; Lewis, 326; Trotter, 1944, 191; Rehman *et al.*, loc. cit.; *Indian For.*, 1952, **78,** 274).

The bark of the tree is said to be used in asthma, consumption and rheumatism; leaves are used in external applications for ulcers (Kirt. & Basu, III, 2156).

M. odoratissima Nees

D.E.P., V, 104; Fl. Br. Ind., V, 139, 859.

HINDI—*Kawala.*

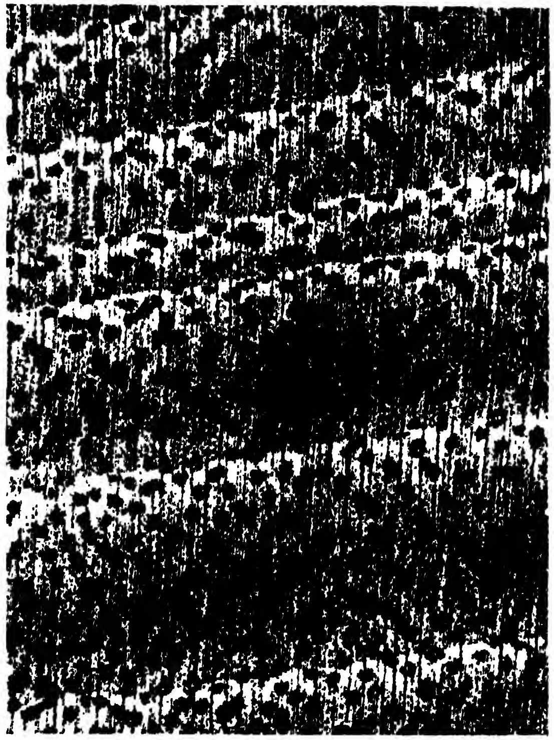
PUNJAB—*Kaula, mithpatta*; NEPAL *Lali kawla*; LEPCHA *Rohun kung*; KHASI *Dieng-la-ngiar-iong.*

TRADE—*Machilus.*

A medium-sized tree, up to 2.4 m. in girth with a bole 7.5 m. long, found throughout the outer Himalayas and Khasi hills up to an altitude of 2,100 m., chiefly in moist ravines and shady places. Bark dark grey, rather rough; leaves crowded at the ends of branches, very variable, oblanceolate to elliptic-oblong, coriaceous; flowers in panicles, yellowish green, fragrant; fruits ellipsoid, purple when ripe.

The tree is a shade-bearer especially when young and is fairly hardy. Natural reproduction takes place by seeds in the early rains shortly after the fall of fruits. Artificial reproduction may be done by transplanting nursery seedlings, one or two years old, at the start of the rainy season. As in *M. macrantha*, special oil-bearing secretory cells are present, but they are smaller and less numerous (Troup, III, 787).

The wood is light yellowish grey when first exposed, ageing to light brown, generally with somewhat darker streaks; heartwood not distinct; fairly straight- to somewhat twisted-grained, fine- and even-textured; moderately strong and heavy (wt., 43 lb./cu. ft.). The wood requires great care in seasoning. In air-seasoning, girdling trees for 2½ years and drying the wood in planks or scantlings for 6 months under cover, gave the best results. Seasoning in the log or green conversion cause considerable splitting; wood seasoned in the log is liable to borer attack. Kiln-seasoning of large planks shows no degrade; the colour, however, slightly darkens. The timber is liable to the attack of fungi. It is easy to work to a



F.R.I., Dehra Dun, Photo: S. S. Ghosh

FIG. 70. MACHILUS ODORATISSIMA—TRANSVERSE SECTION OF WOOD (×10)

good finish and takes polish well. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 100; strength as a beam, 80; stiffness as a beam, 95; suitability as a post, 85; shock-resisting ability, 90; retention of shape, 60; shear, 120; and hardness, 95. The wood is used in building construction as beams, rafters, planking, frames, doors, window sashes, etc.; it is used for shingles in Burma. It is reported to be a useful furniture and plywood timber (Pearson & Brown, II, 839-41; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 54, Sheet No. 13).

Leaves and flowers of the tree are sweet-scented. Leaves are used for rearing *muga* silkworms in Assam. The seeds yield a semi-drying oil with the following characteristics: sp. gr., 0.9260; acid val., 65; sap. val., 170-190; iod. val., 86-118; R. M. val., 3.01; and m.p. of mixed fatty acids, 24-26° [Krishna *et al.*, *Indian For. Rec., N.S., Chem.*, 1936, **1**(1), 13].

M. dubia A. Das & P. C. Kanjilal is a tall tree found in Sibsagar in Assam. It yields a timber which resembles *bonsum* wood (*Phoebe* spp.) of Assam and is sold as its substitute (Fl. Assam, IV, 70).

M. duthiei King ex Hook. f. is a handsome shady tree found in the Himalayas from Chamba to Nepal up to an altitude of 2,700 m. The wood (wt., 36–37 lb./cu. ft.) is grey and moderately hard; it is used as fuel. The tree is lopped for fodder (Gamble, 567: Laurie, *Indian For. Leafl.*, No. 82, 1945, 9: Chatterjee, *Indian For.*, 1953, **79**, 563).

M. edulis King ex Hook. f. (NEPAL—*Lapche phal, lapche kawla*; LEPCHA—*Phum-kung*) is a large tree found in the eastern Himalayas between 1,200 and 2,400 m. and in the hills of Assam. It is an important tree of Darjeeling forests, reproducing freely from seed and growing moderately fast. Its large walnut-like fruits are eaten by the Lepchas. The wood (wt., 39–44 lb./cu. ft.) is light greyish brown in colour, moderately hard, smooth and even-grained; it is used for planking and tea boxes (Gamble, 566: Troup, III, 788).

M. globosa A. Das (ASSAM—*Kaunla*) is a tall tree recorded from Assam. The timber though much inferior to *bonsum* (*Phoebe* spp.) is extensively used as a substitute for the latter (Fl. Assam, IV, 69).

M. villosa Hook. f. (NEPAL—*Surool, kawla*; ASSAM—*Bondai-sum*; ORIYA—*Atilo*) is a moderate-sized to large tree with spreading branches found in the eastern Himalayas up to an altitude of 2,100 m., hills of Assam and in Mayurbhanj (Orissa). The wood (wt., 31 lb./cu.ft.) is yellowish brown, moderately hard and of good texture. It seasons without difficulty, is not liable to warp and is durable. It is used for shingles and also as fuelwood (Gamble, 565: Rodger, 8; Fl. Assam, IV, 66).

Mackay Bean — *see* **Entada**

MACLURA Nutt. (*Moraceae*)

A monotypic genus of trees represented by *M. pomifera* native of North America. It has been introduced into India and is grown in gardens.

M. pomifera Schneid. syn. *M. aurantiaca* Nutt.
OSAGE ORANGE

C.P., 999: Parker, 484: Bailey, 1947, II, 1961, Fig. 2292.

A spiny tree with spreading branches, *c.* 18 m. high and 1.8–2.7 m. in girth, chiefly grown as a hedge plant. Bark brown, deeply longitudinally fissured: leaves ovate or oblong-lanceolate, entire; flowers dioecious, greenish, minute: male flowers long pedicelled, in short or ultimately elongated racemes, female flowers sessile, in dense axillary pedunculate heads; fruit a syncarp, as large as an orange, yellowish green, mamillate.

M. pomifera is propagated by seeds, root cuttings and layers. It is hardy against frost and drought and thrives well in deep soil. The leaves of the plant may be used for rearing mulberry silkworms (Chittenden, III, 1227).

The leaves contain (dry basis): organic matter, 90.04: crude protein, 23.37; fat, 1.87; and ash, 9.96%: the ash is rich in silicic acid, lime and phosphoric acid. The fruit (wt., 1–2.5 lb.) is inedible, but sometimes eaten by cattle; it is suspected to be poisonous to stock, but feeding trials have not given any conclusive results. The dried fruit pulp contains 18% of a fatty oil, which shows promise of being used as an edible oil after purification; the seed kernels contain 42% oil. The resins present in the fruit may be suitable for paints and adhesives. The fruit contains at least four isoflavone pigments, including pomiferin ($C_{25}H_{24}O_6$, m.p. 200.5°) and osajin ($C_{25}H_{24}O_5$, m.p. 189°), with antioxidant activity. The fruit extract is useful as cardiac stimulant. The latex from the plant contains a proteolytic enzyme, macin, which may be used for tenderizing meat and sausage casings (*Chem. Abstr.*, 1935, **29**, 1849; Wehmer, I, 236; Eckey, 388; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 112; Clopton & Roberts, *J. Amer. Oil Chem. Soc.*, 1949, **26**, 470; Schall & Quackenbush, ibid., 1956, **33**, 80: Mayer & Cook, 210; Hocking, 132: *Chem. Abstr.*, 1949, **43**, 1502).

The wood of the plant is very hard, heavy (sp. gr., 0.85–0.90; wt., 53–56 lb./cu. ft.), tough, strong, durable and resilient; it is of a bright orange colour becoming brown on exposure. It is rather difficult to work but finishes to a smooth surface. It can be used for rims of wagon wheels, spokes, insulator pins, treenails, walking sticks, golf shafts, fence posts and agricultural implements. Aqueous extracts of the wood have been used for tanning and dyeing. The wood contains 9–10% tannin; it yields a yellow dye similar to that from old fustic (*Chlorophora tinctoria*) and contains the same colouring principles, viz. maclurin ($C_{13}H_{10}O_6$, m.p. 220–22°) and morin ($C_{15}H_{10}O_7$, m.p. 286–88°). A heat-stable, non-toxic antibiotic, suitable for use as a food preservative, has been extracted from the heartwood and root of the tree (Record & Hess, 389: Howard, 434; Howes, 1953, 281; Thorpe, IX, 133: *Chem. Abstr.*, 1951, **45**, 7724).

MACROPANAX Miq. (*Araliaceae*)

D.E.P., V, 105; Fl. Br. Ind., II, 738.

A small genus of trees or shrubs distributed from Himalayas to Java. Two species are found in India.

M. undulatum Seem. (NEPAL—*Chinde*; LEPCHA—*Prongzam*; ASSAM—*Bon-keseru, dieng-jarasi, phumber*) is a small evergreen tree, 6–9 m. in height, with smooth greyish bark and digitate compound leaves found in eastern Himalayas and Assam up to an altitude of 1,500 m. The gum exuding from the wounds is reported to be aromatic. The wood (wt., 30 lb./cu. ft.) is yellowish white, soft and even-grained (Fl. Assam, II, 363; Gamble, 387).

MACROSOLEN Blume (*Loranthaceae*)

Fl. Br. Ind., V, 220.

A small genus of parasitic shrubs distributed in South-East Asia and New Zealand. Three species occur in India.

M. cochinchinensis (Lour.) Van Tiegh. syn. *Elytranthe cochinchinensis* G. Don; *Loranthus globosus* Roxb.; *L. ampullaceus* Roxb.; *L. cochinchinensis* Lour. (BENG.—*Chhota-manda*; ASSAM—*Raghumala*; NEPAL—*Aijheru*) is a much branched bushy shrub, parasitic on numerous trees and found in Nepal and Sikkim up to 1,200 m., West Bengal, Assam, Khasi, Garo and Aka hills and Andaman Islands. Leaves elliptic, elliptic-lanceolate or ovate; flowers white or greenish yellow. The leaves of the plant are applied as poultice for headache. The plant contains quercitrin and a wax; the ash (8.05%) contains manganese (Burkill, I, 919; Wehmer, I, 262).

*MACROTOMIA DC. (*Boraginaceae*)

A small genus of annual or perennial herbs distributed in Asia and the drier regions of northern Africa. Six species occur in India.

M. benthamii DC. = *Arnebia benthamii* (Wall. ex G. Don) Johnston

D.E.P., V, 106; Fl. Br. Ind., IV, 177; Johnston, *J. Arnold Arbor.*, 1952, **33**, 333; 1954, **35**, 56; Coventry, I, 75, Pl. XXXVII.

KASHMIR—*Kahzaban, gaozaban.*

An erect herbaceous perennial, 30–90 cm. high, found in alpine Himalayas from Kashmir to Kumaon at altitudes of 3,000–3,900 m. and in Nepal. Leaves narrow-lanceolate: radical leaves large, 28.0 cm. × 1.3 cm., cauline leaves 7.5 cm. × 1.3 cm.; flowers pink to purple or maroon, in dense terminal spikes.

The dry plant, on steam-distillation, yields an essential oil in traces. Underground parts contain a purple dye. The plant is considered expectorant and used for cardiac disorders. Aqueous extracts, sherbet (syrup) and jam prepared from the flowering shoots are considered useful in the diseases of tongue and throat and also in fever [Handa *et al.*, *J. sci. industr. Res.*, 1957, **16A**(5), suppl., 26; Hocking, 132; Kirt. & Basu, III, 1697; Kaul, 90].

M. perennis Boiss. = *Arnebia euchroma* (Royle) Johnston

D.E.P., V, 106; Fl. Br. Ind., IV, 177; Johnston, *J. Arnold Arbor.*, 1952, **33**, 333; 1954, **35**, 56; Kirt. & Basu, Pl. 655A.

A herbaceous perennial, 20–50 cm. high, found in western Himalayas from Kashmir to Kumaon at altitudes of 3,000–4,200 m. Leaves oblong: radical leaves 12.5 cm. × 0.8 cm., cauline leaves 2.5–5.0 cm.; flowers purplish white to purple or brownish, in compound cymes.

The plant is reported to be used in Afghanistan for toothache and earache. Bruised roots are applied to eruptions. Underground parts contain a purple or red dye. The root of this plant, along with that of *Onosma hispidum* D. Don and other roots, is said to constitute the *Rattanjot* of Punjab and N.W. Himalayas (Kirt. & Basu, III, 1697).

* Johnston (*J. Arnold Arbor.*, 1954, **35**, 51) has proposed that this genus may be made a synonym of *Arnebia* Forsk.

Mad Apple — *see* **Datura**

Madagascar Plum — *see* **Flacourtia**

Madar Mat — *see* **Cyperus**

Madder, European — *see* **Rubia**

Madder, Indian — *see* **Hedyotis**

MADHUCA J. F. Gmel. (*Sapotaceae*)

A genus of trees distributed from India to Australia and Polynesia. Four species are found in India.

***M. indica** J. F. Gmel. syn. *M. latifolia* Macb.; *Bassia latifolia* Roxb. MAHUA, MOWRA, ILLIPE, BUTTER TREE

D.E.P., I, 406; C.P., 116; Fl. Br. Ind., III, 544.

HINDI—*Mahua, mohwa, mauwa*; BENG.—*Mahwa, maul, mahula*; MAR.—*Mahwa, mohwra*;

* Recently van Royen has revised the taxonomy and nomenclature of the genus *Madhuca* of the Malaysian area. He merges *M. indica* J. F. Gmel. and *M. longifolia* (Koenig) Macb. under the latter name and distinguishes two varieties, viz. var. *longifolia* and var. *latifolia* (Roxb.) Cheval. [*Blumea*, 1960, **10**(1), 53].

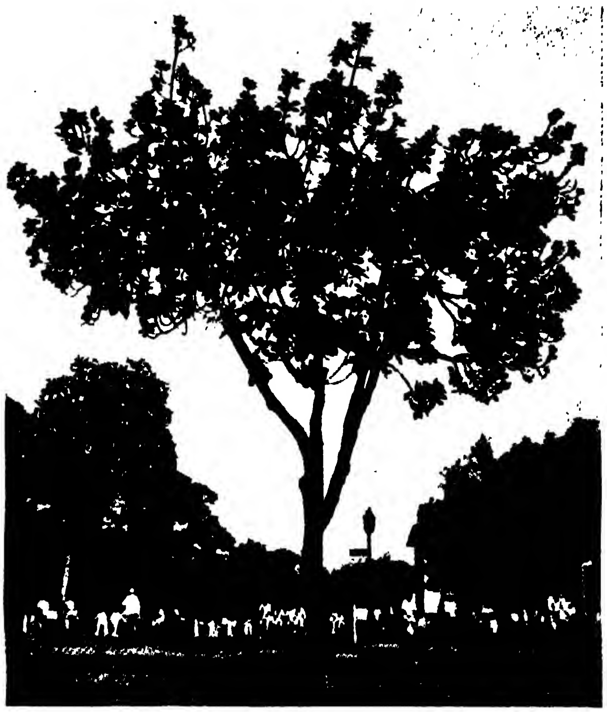


FIG. 71. MADHUCA INDICA—A YOUNG TREE

GUJ.—*Mahuda*; TEL.—*Ippa*; TAM.—*Illupei, elupa*; KAN.—*Hippe*; MAL.—*Poonam, ilupa*; ORIYA—*Mahula, moha, madgi*.

A medium-sized to large deciduous tree, usually with a short bole and large rounded crown, found throughout the greater part of India up to an altitude of 1,200 m. Bark dark coloured, cracked; leaves clustered near ends of branches, elliptic or elliptic-oblong, 7.5–23 cm. x 3.8–11.5 cm., coriaceous, pubescent when young, almost glabrous when mature; flowers in dense fascicles near ends of branches, many, small; calyx coriaceous; corolla tubular, fleshy, cream-coloured, *c.* 1.5 cm. long, scented, caducous; berries ovoid, up to 5 cm. long, greenish turning reddish yellow or orange when ripe; seeds 1–4, brown, ovoid, shining, 2.5–3.75 cm. long.

M. indica is found in mixed deciduous forests, usually of a somewhat dry type, often growing on rocky and sandy soil and thriving on the Deccan trap. It is common throughout central India, Bombay and Andhra Pradesh; it is also common in the drier type of sal forests in Madhya Pradesh. It is much planted in the plains of northern India and Deccan Peninsula. When forest land is cleared for cultivation, mahua trees are carefully preserved.

M. longifolia (Koenig) Macb. syn. *Bassia longifolia* Koenig SOUTH INDIAN MAHUA, MOWRA BUTTER TREE

D.E.P., I, 415; C.P., 117; Fl. Br. Ind., III, 544.

(Names in Indian languages same as those of *M. indica*)

A large evergreen tree with a dense spreading crown found in South India. Bark grey to dark brown, scaly, leaves clustered near ends of branches, linear-lanceolate, 7.5–12.5 cm. x 2.5–4.5 cm., tapering towards base, glabrous when mature; flowers in dense clusters near ends of branches, many, small; calyx rusty pubescent; corolla tubular, fleshy, pale yellow, *c.* 1.5 cm. long, aromatic, caducous; berries ovoid, *c.* 5 cm. long, yellow when ripe; seeds usually 1–2, compressed, yellow, shining. *M. longifolia* replaces *M. indica* in South India and is frequently met with in cultivation, especially as an avenue tree.

M. longifolia is common in the monsoon forests of western ghats from Konkan southwards, usually

FIG. 72. MADHUCA INDICA—FRUITING BRANCH

MADHUCA INDICA — FLOWERING BRANCH

along the banks of rivers and streams ; it also extends into the Deccan and many parts of southern India. It thrives on all types of soils with a considerable depth of loam and may be grown in comparatively dry localities.

M. indica and *M. longifolia* are so closely related that hardly any distinction is made between them in trade. Both are valued for their seeds which yield a fatty oil, known in commerce as Mahua Butter, Mowra Fat, Illeppe Butter or Bassia Fat. The corollas of mahua flowers, commonly called mahua flowers, are edible and form an article of diet in villages in several parts of India. Mahua timber is used for constructional purposes. The information given below applies generally to both species.

Mahua is ordinarily drought- and frost-hardy, but suffers under severe conditions. It is reported to be unaffected by excessive monsoons and is found in water-logged or low-lying clayey and shallow soils in Mysore. It is a strong light-demander and is readily suppressed under shade. When young, it may be browsed by deer and cattle. It coppices fairly well when cut in the dry season, but not when cut during rains. In some localities, particularly in central India, the tree is damaged by loranthaceous parasites.

Natural reproduction takes place by seeds which germinate early in the rainy season, soon after falling. Exposure renders them liable to fungus attack and radicles may dry up or be eaten by insects ; for germination to take place the seeds should become covered with earth or debris. Natural seedlings are thus found chiefly in small hollows into which earth is washed at the commencement of rains. Subsequent growth is slow, but is favoured by abundant light.

Artificial propagation may be done by direct sowing or by transplanting nursery raised seedlings. Fresh seeds should be sown about July–August and covered with earth. Direct sowing in prepared lines or patches is preferred to transplanting which is troublesome as the seedlings develop long and delicate tap-roots. For transplanting, seeds should be either sown direct in deep pots or baskets or seedlings transplanted into them from the nursery during the first rainy season a few weeks after germination ; they are planted in the forest early in the second rainy season (Troup, II, 640–46 ; Krishnamurti Naidu, 45).

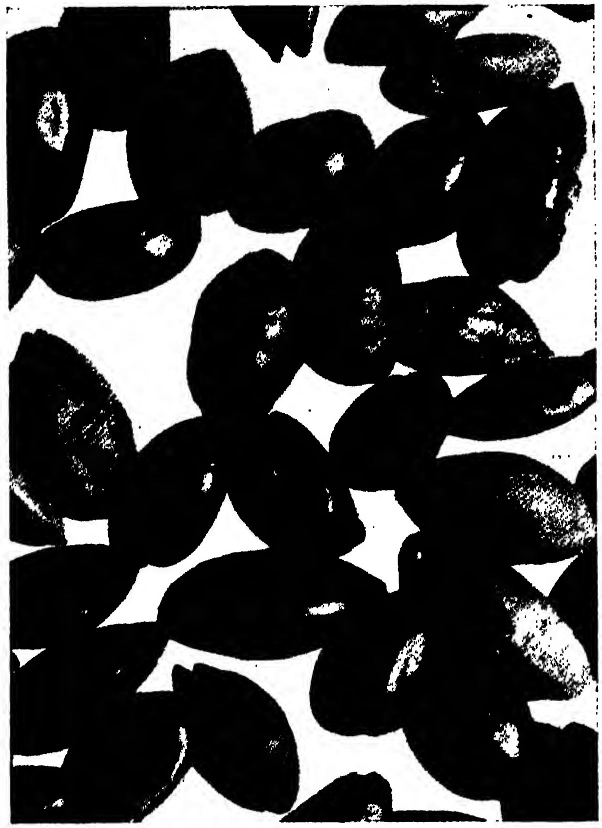


Photo : M. B. Ichaporia

FIG. 73. MAHUA SEEDS—UNSHELLED

Diseases & Pests—*M. indica* is affected by the rust, *Scopella echinulata* (Niessl) Mains syn. *Uromyces echinulatus* Niessl. The tree is also subject to white spongy rot (*Polystictus steinheilianus* Berk. & Lev.), heart rot of stems [*Fomes caryophylli* (Racib.) Bres.] and root and butt rot (*Polyporus gilvus* Schw.) (*Indian J. agric. Sci.*, 1950, **20**, 107 ; Information from F.R.I., Dehra Dun).

The leaves of *M. indica* are eaten by caterpillars of *Achaea janata* Linn., *Anuga multiplicans* Wlk., *Bombotelia nugatrix* Guen., *Metanastria hyrtaca* Cram. and a few species of *Rhodoneura*. Two species of *Acrocercops* mine the leaves and blotch them. Newly felled trees and green logs are attacked by the pin-hole borers, *Xyleborus* spp. and *Polygraphus bassiae* Beeson. The bark is destroyed by white ants (*Odontotermes obesus* Ramb.) and the bark borer, *Xyloctonus scolytoides* Eichh. The sapwood of dead tree is damaged by ghoon borers, like *Schistoceros anobioides* Waterh. and *Xylocis tortilicornis* Lesne (Information from F.R.I., Dehra Dun).

M. longifolia is attacked by the sap sucker, *Unaspis acuminata* Green, and sometimes by white ants,

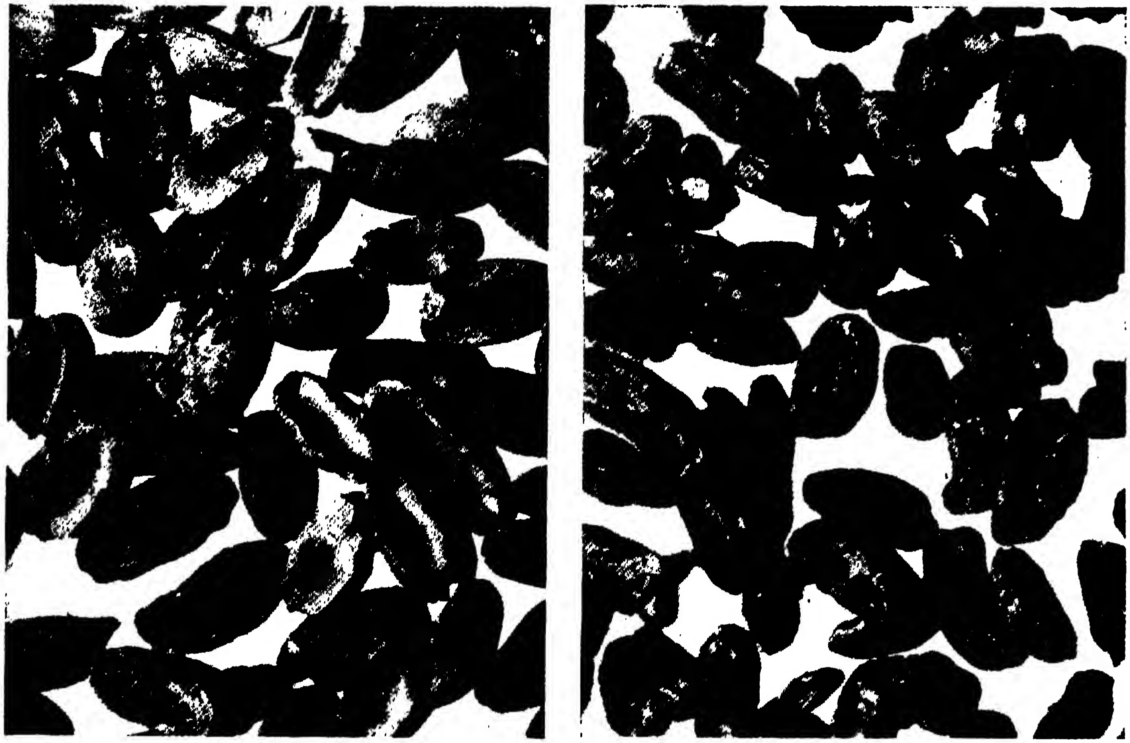


Photo: M. B. Ichaporia

FIG. 74. MAHUA KERNELS—WELL PRESERVED AND SPOILED

Coptotermes ceylonicus Holmg. and *Kalotermes* sp. (Information from F.R.I., Dehra Dun).

Collection of seeds—Under favourable soil and climatic conditions, mahua trees begin to bear fruit at the age of 8-10 years and continue to do so for about 60 years. Fruiting in alternate years is not uncommon.

The fruits ripen in May-June, when they fall from the tree or are dropped by vigorous shaking of the branches. The season for collecting the seeds is short and in the absence of organized harvesting, a considerable portion of the crop is lost during the monsoon. In some parts of South India, harvesting extends up to December. The seeds are separated from the fruit wall by pressing, and then dried and shelled to get the kernel (*c.* 70% of the weight of seed). The kernels constitute the mahua seed of commerce.

No authentic figures are available regarding the total number of mahua trees, yield of seeds per tree and actual production. Available information from some states is summarized in Table 1.

Mahua seeds available in the trade contain 5-12% moisture and 2-5% refraction. Seeds containing more than 7-8% moisture are liable to fungus attack when stored. Analysis of seed kernel gave the following values: fatty oil, 51.1; protein, 8.0; N-free extr., 27.9; fibre, 10.3; and ash, 2.7% (Wehmer, II, 928).

TABLE 1—ESTIMATED PRODUCTION OF MAHUA SEEDS*

State	No. of trees	Annual seed production (tons)
Bombay	737,000	19,732
Mysore	25,000	1,116
Madhya Bharat	522,000	14,574
Bhopal	188,000	2,950
Vindhya Pradesh	1,514,000	18,925
West Bengal	101,700	2,940
Madras	300,000	6,071
Hyderabad	997,900	5,917
Uttar Pradesh	4,995,627	44,643**

* Information from Indian Central Oilseeds Committee.
** *Indian Soap J.*, 1952-53, **18**, 4.

Mahua Oil

The quality of oil expressed from the seeds depends largely on the conditions under which they have been stored. Even under the best conditions of storage, the concentration of free fatty acids increases. The oil from fresh seeds has an acid value as low as 3.5, while the value for oil obtained from old and badly stored seeds may be as high as 60. The yield of oil from seeds depends on the efficiency of the equipment employed for crushing; it is 20–30% of the weight of kernels when crushed in *ghanis*, 34–37% in expellers and 40–43% when extracted by solvents. The oil content of cake from solvent extraction plants is usually less than 1%.

Fresh mahua oil from properly stored seeds is yellow in colour with a not unpleasant taste. Commercial oils are generally greenish yellow in colour with an offensive odour and disagreeable taste. At temperatures prevailing in most parts of India during the major part of the year, the oil is fluid, often throwing out a deposit of stearine: in cold weather, the oil solidifies to a buttery consistency. Mahua oil has the following characteristics: sp. gr.$_{15°}^{100°}$, 0.856-0.870; $n_D^{40°}$, 1.458–1.462; acid val., 5–50; sap. val., 188–200; iod. val., 53–70; R.M. val., 0.7–3.6; unsapon. matter, 1–3%; and titre, 36–45° (Thorpe, I, 653; Williams, K. A., 385; Sudborough *et al.*, *J. Indian Inst. Sci.*, 1923, **6**, 1; Eckey, 712).

The fatty acid composition of mahua oil from Gujarat and Uttar Pradesh is given in Table 2. The glyceride structure of the oil is reported to be as follows: dipalmito-stearins, 1; oleo-dipalmitins, 1; oleo-palmitostearins, 27; palmito-dioleins, 41; and stearo-dioleins, 30% mol. According to more recent work, the values are: trisaturated, trace; mono-unsaturated-disaturated, 47; mono-saturated-diunsaturated, 36; and tri-unsaturated, 17% mol. (Hilditch & Ichaporia, *J. Soc. chem. Ind., Lond.*, 1938, **57**, 44T; Kartha, *J. Amer. Oil Chem. Soc.*, 1953, **30**, 326).

The unsaponifiable matter contains an unsaturated hydrocarbon, illipene ($C_{32}H_{56}$ or $C_{61}H_{106}$ or $C_{65}H_{108}$, m.p. 64.5°), 2 sterols (m.p. 177° and 122°, the latter having the molecular formula $C_{29}H_{50}O$ and probably isomeric with β- and γ-sitosterol), higher fatty alcohols and colouring matter (Kobayashi, *J. Soc. chem. Ind. Japan*, 1922, **25**, 1188; Srivastava & Rao, *Soap Perfum. Cosm.*, 1951, **24**, 673; Bhargava & Singh, *J. Indian chem. Soc.*, 1958, **35**, 763; Heilbron & Bunbury, III, 2).

TABLE 2—COMPONENT FATTY ACIDS OF MAHUA OIL
(% of total fatty acids)

	Gujarat		U.P.
	Sample A[1]	Sample B[2]	Sample C[3]
Myristic	16.3	..	1.2
Palmitic	27.1	23.7	17.4
Stearic	2.0	19.3	24.5
Arachidic	..	..	3.0
Oleic	41.0	43.3	44.6
Linoleic	13.6	13.7	9.3

[1] Gill & Shah, *Oil Fat Ind.*, 1925, **2**, 46; [2] Hilditch & Ichaporia, *J. Soc. chem. Ind., Lond.*, 1938, **57**, 44T; [3] Dhingra *et al.*, ibid., 1933, **52**, 116T.

TABLE 3—QUANTITIES OF MAHUA SEED CRUSHED AND OIL PRODUCED IN MILLS (1950-54)
(tons)

	1950		1951		1952		1953		1954	
	Seed	Oil	Seed	Oil	Seed	Oil	Seed	Oil	Seed	Oil
Bombay	10,003	3,852	11,517	4,419	5,756	2,134	5,019	2,063	5,287	2,094
West Bengal	3,395	1,156	3,567	1,200	1,853	621	2,168	764	2,873	919
Uttar Pradesh	7,970	2,836	15,232	5,437	9,739	3,391	6,013	2,122	5,327	1,817
Bihar	160	53	148	45	4	1	2	1	10	3
Madhya Pradesh	440	143	481	158	582	185	321	103	794	254
Punjab	173	60	87	31	350	124	128	41	183	68
Orissa	215	59	129	45	95	31	..	..	..	..
Rajasthan	5	2	251	97	140	52	111	41	140	52
Others	32	11	..	..	79	20	35	11	88	28
Total	22,393	8,172	31,412	11,432	18,598	6,559	13,797	5,146	14,702	5,265

Table 3 gives the quantities of seed crushed and oil produced in different States by factories registered under the Factories Act, during the period 1950–54. Figures for seeds crushed and oil produced during 1954–55 and 1955–56 (Table 4) are only approximate as they do not relate to all the mills in the country. In addition to the oil produced by organized mills, a sizeable quantity of seeds is crushed in village *ghanis*; about 10,000 tons of seeds were crushed in *ghanis* in 1953–54; a more recent estimate puts it at 15,000 tons.

Indian Standard Specifications (IS: 545-1954) for mahua oil are as follows: moisture, $\ngtr 0.25\%$; colour (Lovibond $\frac{1}{4}$ in. cell) Y+5R, $\ngtr 30$; sp. gr.$^{25}_{30}$, 0.862–0.875; n^{40}, 1.459–1.461; acid val., $\ngtr 40.0$; sap. val., 187–196; iod. val., 58–70; unsapon. matter, $\ngtr 3.0\%$; and titre, $\nless 38°$; the filtered sample kept at 50° for 24 hr. shall show no turbidity.

Uses—Mahua oil is used mainly in the manufacture of soaps, particularly laundry soaps. The quantities consumed by the Indian soap industry during 1950–54 are given in Table 5. Soap produced from mahua oil tends to go rancid during storage, due mainly to the presence of oxidisable constituents in the unsaponifiable fraction. For this reason, mahua oil is not recommended for toilet soap manufacture, unless it is protected by a suitable anti-oxidant. It has been reported that treatment of oil with steam before saponification and addition of gum benzoin, along with tobacco or clove extract during processing, renders the oil suitable for the production of high quality soaps. The use of distilled mahua fatty acids for the same purpose has been recommended (Wittka, *Allg. Oel-u. Fettztg*, 1933, **30,** 381; Om Prakash *et al.*, *Proc. Indian Sci. Congr.*, 1956, pt III, 160; *Chem. Abstr.*, 1952, **46,** 8396; Srivastava & Rao, loc. cit.).

TABLE 4—QUANTITIES OF MAHUA SEED CRUSHED AND OIL PRODUCED (1954-56)*
(in metric tons)

	1954–55	1955–56
Seed	22,187	30,653
Oil	7,179	10,578

* *Report on Power Oil Milling Industry*, Indian Oilseeds Comm., 1954–56.

TABLE 5—CONSUMPTION OF MAHUA OIL IN INDIAN SOAP INDUSTRY*

	Qty (tons)	Val. (Rs.)
1950	5,480	9,838,642
1951	8,330	15,803,000
1952	3,910	5,978,937
1953	1,737	2,859,979
1954	1,879	2,253,594

* *Census of Indian Manufactures.*

Mahua oil is used for edible and cooking purposes in some rural areas. Crude oil has a deep colour, high acidity and unpleasant odour. Refining and hydrogenation yield products similar to mutton tallow or cacao butter. Oils having acid value below 13 may be refined by treatment with caustic soda; those with higher acid value are extracted with alcohol and further treated with alkali. The oil is sometimes used as an adulterant for ghee; for this purpose it is clarified with buttermilk to mask the odour (Hodge, *Econ. Bot.*, 1955, **9,** 99; Hill, 205; Kane, *Proc. Symp. Indian Oils & Fats*, NCL, Poona, 1951, 55; Sudborough *et al.*, loc. cit.).

Refined oil finds use in the manufacture of lubricating greases and fatty alcohols. The oil is used also for candles, as a batching oil in jute industry and as a raw material for the production of stearic acid [IS: 545, 1954; Thiagarajan & Srikantan, *J. Indian chem. Soc., industr. Edn*, 1950, **13,** 163, 201, 210, 219, 227; Kane & Kulkarni, *J. sci. industr. Res.*, 1954, **13B,** 890; Patnaik, *Oils & Oilseeds J.*, 1950–51, **3** (11), 9].

Mahua oil has emollient properties and is used in skin diseases, rheumatism and headache. It is laxative and considered useful in habitual constipation, piles and haemorrhoids; it is used also as an emetic. The seeds are galactagogue (Chopra, 1958, 358; Dastur, Medicinal Plants, 151; I.P.C., 145; Nayar, *J. Bombay nat. Hist. Soc.*, 1954–55, **52,** 515).

Marketing—Mahua being essentially a forest crop, the collection and transport of seeds on an organized basis presents certain difficulties; also the proportion of seeds collected to the total crop is much less in forest areas than around villages where mahua trees occur in a state of semi-cultivation.

Shelled kernels which are not locally crushed in *ghanis* reach the market after passing through several intermediaries. The more important terminal markets for mahua seeds in different states are: *Uttar Pradesh*—Mauranipur (probably the biggest market in the country), Lalitpur, Mahoba, Bharwari and Allahabad; *Madhya Pradesh*—Alirajpur, Shajapur, Ujjain, Basoda, Kannod, Betulganj, Raipur,

Bhopal and Itarsi; *Maharashtra*—Chanda, Nandurbar and Nasik; *Gujarat*—Godhra; *Orissa*—Gunpur; *Andhra Pradesh*—Rajahmundry, Visakhapatnam, Bobbili and Parvatipuram; *Mysore*—Tumkur. The bulk of transactions between merchants and millers, however, take place in Bombay, Calcutta and Kanpur.

The price of mahua oil in the Bombay market is generally higher than that of imported Malayan palm oil (Fig. 75). It is influenced, to a certain extent, by the prices of coconut and groundnut oils which are also consumed in the soap industry. The recent upward trend in the price of mahua oil is due mainly to restrictions on the imports of palm oil and coconut oil.

Exports- Prior to World War I, considerable quantities of mahua seed (av. 30,000 tons per annum) were exported to Europe. There has been a steep drop in exports since the war and in recent years there has been practically no export of seed or oil. During the past 3 or 4 years a small quantity of oil has been exported, mainly to Pakistan. In 1960, 519 cwt. of oil valued at Rs. 51,225 were exported.

Mahua Cake

Analysis of mahua cake (from U.P.) gave the following values: moisture, 7.2–11.1; oil, 8.0–13.3; protein, 15.0–17.4; carbohydrates, 48.7–54.6; fibre, 5.3–5.9; and ash, 6.4–6.8%. It contains c. 4.6% of a

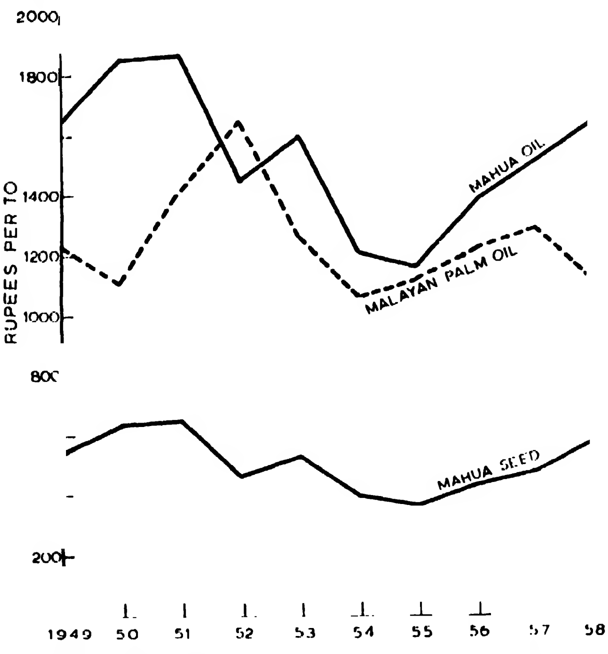


FIG. 75. PRICES (Rs./ton) OF MAHUA SEED AND OIL (1949-58)

toxic and bitter saponin, mowrin, which possesses a digitalis-like action on the heart and also haemolytic action; it is regarded by some as a mixture of two substances. On hydrolysis, mowrin yields the sapogenin, bassic acid ($C_{30}H_{46}O_5$, m.p. 319–24°) and glucose, rhamnose, arabinose and xylose. In comparison with other oilseed cakes, mahua cake is poor in protein content (Om Prakash *et al.*, *J. Instn Chem. India*, 1953, **25**, 31; Chopra, 1958, 357; U.S.D., 1947, 1359; Saletore & Pandharipande, *J. Indian chem. Soc., industr. Edn*, 1949, **12,** 125; Dutta, *Curr. Sci.*, 1954, **23,** 222; *Chem. Abstr.*, 1939, **33,** 7809).

The presence of saponin renders the cake unfit for use as animal feed. Small quantities of cake are sometimes fed to cattle without any apparent ill effect. Processes have been worked out in Germany for eliminating saponin from the cake: processed cake can be used in animal feeds in admixture with other materials, particularly molasses (*Oilseeds Ser., Indian Oilseeds Comm.*, No. 33; Oil Seeds and Feeding Cakes, 98).

Mahua cake is used as manure either alone or in mixture with other cakes and ammonium sulphate. It contains: N, 2.5; phosphorus (P_2O_5), 0.97; and potassium (K_2O), 2.15%. The presence of saponin inhibits the rapid nitrification of cake in the soil; for this reason, mahua cake should be applied a few weeks earlier than the normal time for the application of other seed cakes. A compost with good manurial value is obtained by mixing 2 parts of mahua cake with 25 parts of soil, 5 parts of charcoal and 65–70 parts of water and setting the mixture aside for 6 months to ferment. Composting with sawdust, bagasse and cane trash for 3 months facilitates nitrification of cake. In recent years, mahua cake is being exported to Ceylon, U.K. and a few other countries. The quantity of cake exported during 1958, 1959 and 1960 amounted to 1,739, 1,166 and 1,018 tons respectively, valued at nearly 2 lakhs of rupees annually [Mukerji, *Agric. Anim. Husb., Uttar Pradesh*, 1951, **2** (1), 14; Vyas, *Bull. agric. Res. Inst. Pusa*, No. 176, 1928; Om Prakash *et al.*, *J. Instn Chem. India*, 1953, **25,** 31; *Oilseeds Ser., Indian Oilseeds Comm.*, No. 33].

Mahua cake possesses insecticidal and piscicidal properties. It is applied to lawns and golf greens, as the saponin present in it has a specific action against earthworms. The cake may be used in the formulation of moulding powder compositions. It is used, along with shikakai (*Acacia concinna*), as a hair-

wash in South India (Subba Rao, *Indian Soap J.*, 1952 53. **18,** 90; Chopra *et al.*, *J. Bombay nat. Hist. Soc.*, 1941–42, **42,** 854; Om Prakash *et al.*, *Proc. Indian Sci. Congr.*, 1951, pt III, 99).

Active carbon with good bleaching properties has been prepared from the husks of mahua seed. Seed husks contain: moisture, 3.1; lignin, 28.6; and crude fibre, 52.6% (Om Prakash *et al.*, *J. Oil Technol. Ass. India*, 1955, **11,** 58).

Mahua Flowers

The succulent, cream-coloured corollas fall to the ground in showers during March and April; in some parts of South India, this continues in other months also. They are collected on previously cleaned ground and spread in the open for drying. During this process, they shrink in size and turn reddish brown in colour; the characteristic odour increases as a result of drying. The yield of corollas per tree varies from 2 to 4 md., though yields up to 8 md. have been reported.

The corollas are a rich source of sugars and contain appreciable amounts of vitamins and calcium. Analysis of a sample gave the following values: moisture, 18.6; protein, 4.4; fat, 0.5; total sugars, 72.9; fibre, 1.7; and ash, 2.7%; phosphorus, 140; calcium, 140; and iron, 15 mg./100 g.; magnesium and copper are present. The sugars identified are sucrose, maltose, glucose, fructose, arabinose and rhamnose. The total sugar content of the corollas is maximum when the flowers are mature and ready to fall. In the growing stage, fructose is present in a greater amount than glucose, and in the ripe stage, the quantities are almost equal; sucrose increases in amount up to the shedding of the corolla; it is later converted into invert sugar (Belavady & Balasubramanian, *Indian J. agric. Sci.*, 1959, **29,** 151; Sutaria & Magar, *J. Indian chem. Soc., industr. Edn*, 1955, **18,** 43, 59; Fowler *et al.*, *J. Indian Inst. Sci.*, 1920–21, **3,** 81).

The vitamins present in the corollas are: carotene (as vitamin A), 39 i.u.; ascorbic acid, 7 mg.; thiamine, 32 μg.; riboflavin, 878 μg.; and niacin, 5.2 mg./100 g.; folic acid, pantothenic acid, biotin and inositol are present. Ascorbic acid is destroyed during drying and storage by the oxidase present. The corollas also contain an essential oil with an unpleasant odour, anthocyanins, betaine and salts of malic and succinic acids. Catalase, oxidase, invertase, maltase, amylase and emulsin are among the enzymes identified (Belavady & Balasubramanian, loc. cit.; Sutaria & Magar, *J. Indian chem. Soc., industr. Edn*, 1955, **18,** 59; Fowler *et al.*, loc. cit.).

Uses—Mahua flowers are eaten raw or cooked; they are eaten also after frying or baking into cakes. More usually, the corolla tubes, after removing the stamens, are boiled for about 6 hr. and left to simmer until the water evaporates completely; the odour disappears as a result of cooking and the material becomes soft and juicy; it is eaten with rice, tamarind, sal seeds, grains or other foods or as sweetmeat. Mahua corollas should be consumed in moderate quantities; excessive consumption may cause vomiting with cerebral symptoms (Trotter, 1940, 258; Chopra *et al.*, 628).

Mahua flowers are largely used in the preparation of distilled liquors. The freshly prepared liquor has a strong, smoky foetid odour, which disappears on ageing. It is reported to excite gastric irritation and produce other unpleasant effects. Redistilled and carefully prepared liquors are of good quality and closely resemble Irish whisky. The corollas were formerly exported to France for distillation of cheap brandy (Trotter, 1940, 258; Thorpe, VII, 470).

Next to cane molasses, mahua flowers constitute the most important raw material for the fermentative production of alcohol. An average yield of 90 gal. of 95% alcohol is reported from 1 ton of dried flowers. A medium containing mahua flowers in 20% concentration (macerated in a food blender and extracted at 180°F. for 30 min.) is used for fermentation; addition of 0.2-0.6% of ammonium sulphate or phosphate, or 5% spent flowers to the medium gives better yields. Table 6 shows the quantity and value of mahua flowers consumed in Indian distilleries during the period 1950–1954. There has been a fall in the consumption of mahua flowers for the production of alcohol in recent years due largely to the increased use of molasses as raw material. However, the use of mahua flowers for alcohol production is likely to continue in localities where they are

TABLE 6—CONSUMPTION OF MAHUA FLOWERS BY DISTILLERS

	Qty (tons)	Val. (Rs.)
1950	7,154	10,51,583
1951	6,624	11,12,622
1952	1,852	3,76,624
1953	2,005	3,61,823
1954	3,672	4,99,927

available at low cost and where alcohol is intended for use as potable spirits (Chatterji, *J. sci. industr. Res.*, 1944-45, **3**, 265; Mande *et al.*, *Industr. Engng Chem.*, 1949, **41**, 1451; *Rep. Alcohol Comm.*, Minist. Comm. & Ind., Govt. of India, 1956, 29).

The flowers are used for the preparation of vinegar. They have also been tried for acetone fermentation. A syrup of good quality is prepared from the flowers by extraction with hot water, clarification with activated charcoal and evaporation under vacuum. The syrup (sugar content, 61%) has a golden yellow colour with the odour of fresh flowers. It is suitable for use in jams and sweetmeats and as a substitute for honey (Thorpe, VII, 470; I, 655; Gokhale, *J. Indian Inst. Sci.*, 1925, **8A**, 84; Walawalkar, *J. Indian chem. Soc.*, 1936, **13**, 657; Sutaria & Magar, *J. Indian chem. Soc., industr. Edn*, 1955, **18**, 75).

The flowers are used as feed for livestock; spent flowers after fermentation are also used as feed. They are relished by cattle and when fed as a part of the concentrate mixture, they have no adverse effect on the yield and quality of milk. The nutritive value of the flowers as shown by feeding trials on Kumaoni bulls, is as follows (dry basis): digestible crude protein, 3.68; total digestible nutrients, 73.7; and starch equivalent, 55.1 lb./100 lb. The flesh of animals, particularly pigs, fed on mahua flowers acquires a delicate flavour (Thorpe, I, 655; Chandra & Johri, *Proc. Indian Sci. Congr.*, 1953, pt III, 251).

Mahua flowers are regarded as cooling, tonic and demulcent. They are used in coughs, colds and bronchitis. Mahua flowers show anti-bacterial activity against *Escherichia coli.* The honey from the flowers is edible and is reported to be used for eye diseases (Kirt. & Basu, II, 1489; U.S.D., 1947, 1359; Joshi & Magar, *J. sci. industr. Res.*, 1952, **11B**, 261; Schery, 343).

Mahua Timber

Mahua tree yields a constructional timber, but the tree is too valuable to be felled for this purpose unless very old. The sapwood is reddish white to brownish white; heartwood light to dark red or reddish brown, dull. The wood is more or less straight- or shallowly interlocked-grained, coarse- to even-textured, very strong, hard and heavy (sp. gr., 0.95–0.97; wt., 61-62 lb./cu. ft.).

Mahua wood is refractory and liable to split and crack. Green conversion of logs, followed by immer-

F.R.I., Dehra Dun. Photo: S. S. Ghosh

FIG. 76. MADHUCA INDICA—TRANSVERSE SECTION OF WOOD (×10

sion in water and subsequent drying of planks under cover in fairly close piles, has been recommended. The wood is durable; graveyard tests show an average life of 10–15 years. It lasts exceptionally well under water. The heartwood is difficult to treat with antiseptic oil but the sapwood treats readily. It is difficult to saw but planes easily to a dull smooth surface and takes a fair polish. It turns well on a lathe but requires a good deal of hand finishing. The data for the comparative suitability of *M. indica* timber, expressed as percentages of the same properties of teak, are: wt., 135; strength as a beam, 75; stiffness as a beam, 80; suitability as a post, 75; shock-resisting ability, 100; retention of shape, 50; shear, 120; and hardness, 165 (Pearson & Brown, II, 673-78; Gamble, 448; Trotter, 1944, 12; Purushotham *et al.*, *Indian For.*, 1953, **79**, 49; Limaye, *Indian For. Rec.*, *N.S.*, *Timb. Mech.*, 1954, **1**, 45, Sheet No. 4).

The wood is used for building purposes as beams, door and window frames and especially posts. It is used for carriages, furniture, turnery, sports goods, musical instruments, oil and sugar presses, ship building, boats, bridges and well construction. Well-

seasoned wood is suitable for agricultural implements, drums and carving. It has been tried for railway sleepers. It is a good fuelwood; calorific value: *sapwood*— 4,890–4,978 cal., 8,802–8,962 B.t.u.; *heartwood*— 5,005–5,224 cal., 9,010–9,404 B.t.u. (Pearson & Brown, II, 673–78; Kapadia, *J. Gujarat Res. Soc.*, 1954, **16,** 15, 20–22; Krishnamurti Naidu, 46; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 12).

Minor Uses

Mahua berries are eaten raw or cooked. They are also eaten by cattle, sheep, goats, monkeys and parrots. They are also medicinal (Dastur, Useful Plants, 140–41; Iyyar & Reddy, *Indian For.*, 1942, **68,** 435; Benthall, 292; Lewis, 247).

Analysis of the ripe fruit gave the following values: moisture, 73.64; protein, 1.37; fat (ether extr.), 1.61; carbohydrates, 22.69; and mineral matter, 0.69%: calcium, 45 mg.; phosphorus, 22 mg.; iron, 1.1 mg.; carotene (as vitamin A), 512 i.u.; and ascorbic acid, 40.5 mg./100 g.; tannins are present. The fruits collected near the ripening stage are rich in starch; the starch is hydrolysed into sugars within 2–3 days after plucking. The fruit pulp may be used as a source of sugar for alcoholic fermentation; one ton of dry fruits, freed from seeds, yield *c.* 29 gallons of absolute alcohol (*Rep. Dep. Nutr. Govt. Bombay*, 1957, 26; Fowler & Dinanath, *J. Indian Inst. Sci.*, 1923, **6,** 131).

Steam-distillation of fruits yields 0.03% of a bright yellow volatile oil with a spicy odour. It has the following constants: sp. gr.$^{34°}$, 0.8945; $n^{34°}$, 1.5025; $[\alpha]_D$, −9.0°; acid val., 27.8; sap. val., 60.92; and sap. val. after acetylation, 137.2. The oil contains: ethyl cinnamate, 22.7; α-terpineol, 3.5; and sesquiterpene and sesquiterpene alcohol, 67.9% (Nigam & Dutt, *Indian Soap J.*, 1945–46, **11,** 131).

Mahua leaves are astringent and are used in embrocations. Leaves are eaten by cattle; they are also used as green manure. Analysis of green leaves gave the following values: moisture, 78.95; organic matter, 19.60; N, 0.43; mineral matter, 1.45; potash (K_2O), 0.43; phosphoric acid (P_2O_5), 0.087; and silica, 0.10% (Kirt. & Basu, II, 1489; Chopra, 1958, 358; Iyyar & Reddy, loc. cit.; Mollison, *Agric. Ledger*, 1901, 36).

A milky latex exudes from incisions and cracks made in the bark. On coagulation it yields a rubbery product resembling gutta percha. Analysis of various samples of coagulum gave the following values: caoutchouc, 12.2–19.9; resin, 48.9–75.8; and insolubles, 11.9–38.9%. The bark contains 17% tannin and is used in dyeing and tanning. It is used also for rheumatism, ulcers, itches, bleeding and spongy gums, tonsilitis and diabetes mellitus. It is given to horses for stomach-ache. The roots are applied to ulcers (Shankernath, *Indian For.*, 1906, **32,** 399; Budhiraja & Beri, *Indian For. Leafl.*, No. 70, 1944, 9; U.S.D., 1947, 1359; Hooper, *Agric. ledger*, 1902, 46; Kirt. & Basu, II, 1489; Dastur, Medicinal Plants, 150; Rama Rao, 237; Bressers, 86).

M. neriifolia (Moon) H. J. Lam syn. *M. malabarica* Parker; *Bassia malabarica* Bedd. is a small to medium-sized tree found on the western coast and ghats from Kanara southwards, usually along banks of streams. It is often not discriminated from *M. longifolia*. The wood of this tree is liable to attack by borers; it is scarcely used except as fuel (Talbot, II, 160).

M. bourdillonii (Gamble) H. J. Lam syn. *Bassia bourdillonii* Gamble (Mal. *Thandidiyan*) is a medium-sized tree found in parts of Travancore up to an altitude of 300 m. It is reported to yield strong timber of good quality (Fl. Madras, 763).

Madhuca butyracea — *see* **Diploknema**

MAERUA Forsk. (*Capparidaceae*)

A genus of climbing shrubs or small trees distributed in tropical Africa and Asia. One species occurs in India.

M. arenaria Hook. f. & Thoms.

Fl. Br. Ind., I, 171.

Guj.—*Vika, vaka*; Tel.—*Bhucakramu, puttatige*; Tam.—*Mulmurandai, bhumichakkarai*.

A large woody climbing shrub found in dry areas in Punjab, upper Gangetic plain, Madhya Pradesh, Rajasthan, Gujarat, Deccan and Carnatic districts from Godavari southwards. Leaves elliptic-oblong; flowers white or greenish yellow, in corymbs; berries elongated, twisted, knotted, deeply constricted between seeds.

The root of the plant resembles liquorice root in appearance and taste, and is said to possess alterative, tonic and stimulant properties. The unripe fruit of a variety, var. *glabra* Hook. f. & Thoms., recorded from Punjab, upper Gangetic plain, central and South India, is eaten after being boiled (Nadkarni, I, 760; Kirt. & Basu, I, 190; Duthie, I, 51).

MAESA Forsk. (*Myrsinaceae*)

A large genus of shrubs and small trees distributed throughout the tropics of the Old World. About 25 species occur in India.

M. indica Wall.

D.E.P., V, 106; Fl. Br. Ind., III, 509; Talbot, II, Fig. 367.

BENG.—*Ramjani*; MAR. *Atki*; KAN. *Guddehargi*; MAL.—*Kirithi*.

GARHWAL—*Gadchiana, jiundali*; KUMAON—*Nagapadhera*; NEPAL—*Bilaune*; LEPCHA—*Purmo-kung*; ASSAM—*Awua-pat, machh-pora*; KHASI—*Dieng-sohjala-tyrkai*; GARO—*Samnakhatok*; LUSHAI—*Arngen*.

A shrub or small tree, 1.2–9.0 m. high, found in hilly regions almost throughout the greater part of India ascending up to 1,800 m. Leaves elliptic-lanceolate or ovate-oblong, regularly or irregularly serrate-dentate; flowers white, fragrant, in axillary racemes; fruit a small globose berry, *c.* 3.0 mm. diam., pinkish white, succulent when ripe.

The leaves of the plant are used in curries in North Kanara. The fruits are edible and are considered anthelmintic. Both leaves and fruits are used as fish poison; extracts of branchlets, leaves, bark and stem exhibit insecticidal activity. The wood of the plant is soft; it is used for house posts and as fuel. Var. *perrottetiana* C. B. Clarke (syn. *M. perrottetiana* A. DC.), found in western ghats, has uses similar to those of *M. indica* (Talbot, II, 145; Kirt. & Basu, II, 1483; Cooke, II, 82; Heal *et al., Lloydia,* 1950, **13,** 132).

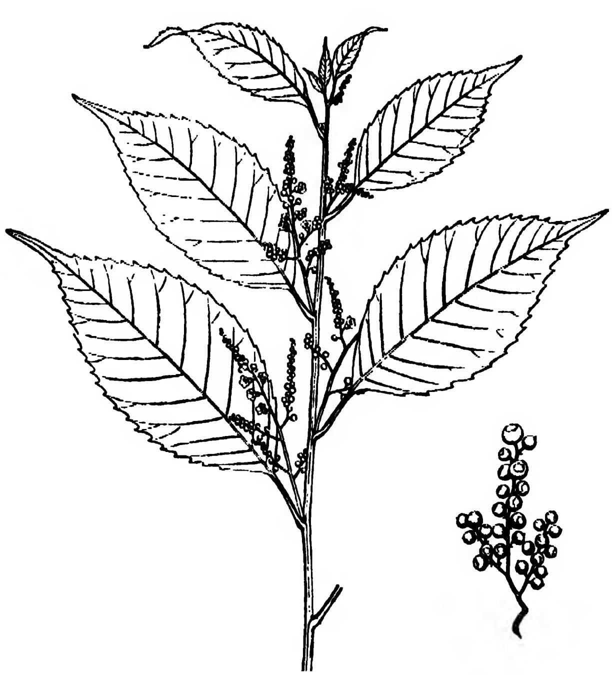


FIG. 77. MAESA INDICA—FLOWERING BRANCH AND FRUITS

M. ramentacea Wall.

Fl. Br. Ind., III, 508.

ASSAM—*Seketia*; KHASI—*Dieng-soh-eit-iar*; NAGA—*Lajachio*; GARO—*Bol-jakhandok, thebeloa*; VISAKHAPATNAM—*Kokkidi*.

A small tree, 7.5–9.0 m. in height, found in Nepal, Bhutan, Assam and north-east Himalayas, Anantagiri hills (Visakhapatnam) and Andaman Islands. Leaves ovate-lanceolate to elliptic-lanceolate; flowers white, in axillary compound racemes; fruits small, succulent, dull brownish white.

The wood is pale brown or brown and fairly hard; it is used for treenails in boat-building. In Malaya, pounded leaves are used as an external application for itches and other skin affections (Kurz, II, 99; Burkill, II, 1392).

M. argentea Wall. (HINDI—*Phusera, gogsa*) is a large shrub with elliptic or elliptic-oblong leaves and whitish or pale greenish yellow flowers found in the outer Himalayas from Garhwal to Sikkim and Khasi and Jaintia hills up to 2,400 m. It bears globose, pinkish or nearly white, succulent berries which are eaten by hill tribes.

M. chisia D. Don (ASSAM—*Susi-porma*; KHASI—*Ja-siet, dieng-ja-sim*; NEPAL—*Bilouni*; LEPCHA—*Purmo-kung*) is a shrub or small tree with lanceolate or elliptic leaves and white, spongy, juicy fruit found from Nepal to Assam ascending up to 2,100 m. Young shoots and fruits are eaten. Roots, bark, branchlets and leaves are reported to show insecticidal activity (Fl. Assam, III, 164; Heal *et al., Lloydia,* 1950, **13,** 132).

M. macrophylla Wall. (KUMAON—*Phusera*; NEPAL—*Bogote*; LEPCHA—*Kalun-kung*) and *M. rugosa* C. B. Clarke are large shrubs or small trees found in eastern Himalayas from Nepal to Bhutan and in northern Bengal. The wood of these plants is light brown; the sapwood is resinous.

M. pyrifolia Miq. syn. *M. indica* var. *latifolia* Hook. f. & Thoms. is a small shrub or tree with ovate leaves found in Khasi hills. The leaves and bark of this plant are reported to contain a saponin and probably a chromo-glycoside (Wehmer, II, 925).

MAGNESITE

Magnesite ($MgCO_3$: H., 3.5-4.5 ; sp. gr., 2.82-3.13) occurs in crystalline and crypto-crystalline forms, associated with iron oxide, lime and silica. The natural crystals belong to the trigonal system and are isomorphous with the carbonates of calcium or calcium and magnesium (calcite or dolomite).

The crystalline variety is usually found in bedded deposits associated with limestone and dolomite. It is reddish brown in colour, due to the presence of ferruginous impurities, and shows distinct lines of cleavage. The amorphous variety occurs in irregular veins or fracture zones of ultrabasic rocks, such as peridotite, serpentine, dunite and steatite. It is usually white in colour and chalky in structure.

The principal magnesite producing countries of the world are Australia, Austria, Canada, Greece, India, U.S.A., U.S.S.R. and Yugoslavia (Table 1). The chemical composition of the more important magnesite deposits of the world is given in Table 2.

TABLE 1—PRODUCTION OF MAGNESITE IN SOME PRINCIPAL PRODUCING COUNTRIES*
(in thousand metric tons)

	1957	1958	1959†
Austria	1,173	1,221	1,116
U.S.A.	615	447	539
Yugoslavia	212	223	229
India	90	104	158
Australia	84	69	56
Greece	47	70	68
World total (incl. others)†	5,100	5,400	5,300

* *Indian Minerals Yearbook*, Indian Bureau of Mines, 1959, 216 ; † Estimated.

TABLE 2—CHEMICAL COMPOSITION (%) OF THE IMPORTANT MAGNESITE DEPOSITS IN VARIOUS COUNTRIES

	MgO	CaO	Fe_2O_3 & Al_2O_3	SiO_2	CO_2 & H_2O
Canada	38.4	9.5	1.0	1.7	49.4
India	46.6	0.5	0.2	1.0	51.7
Greece	46.4	0.7	0.4	1.4	51.1
U.S.S.R.	44.1	3.8	0.9	0.6	50.6
U.S.A.	43.5	1.0	1.5	1.5	52.5
Austria	43.1	1.1	4.3	1.6	49.9

TABLE 3—ANALYSES (%) OF MAGNESITE ORE FROM CHALK HILLS AREA, SALEM DIST.*

	1		3
Silica	1.85	0.70	0.6
Iron oxide & alumina	0.08	0.40	0.3
Lime	0.81	0.60	..
Magnesia	46.41	47.85	47.40
Loss on ignition	50.64	50.40	51.70

* Aiyengar, *Bull. geol. Surv. India, Ser. A*, No. 6, 1953, 19.
1. data supplied by *Magnesite Syndicate*, Salem ; 2. sample from Chettichavadi ; 3. sample from Salem area.

Distribution in India

Magnesite occurs mainly in Madras and Mysore States and in Uttar Pradesh. The estimated reserves in workable deposits are over 110 million tons. Of these, 83 million tons occur in Madras State.

Andhra Pradesh—In Kurnool district, appreciable quantities of magnesite occur associated with steatite near Muddavaram (15°30′:78°6′) and Musalacheruvu near Betamcherla. The mineral is mixed up with calcareous and clayey impurities ; the deposits are not exploited (Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 199).

Bihar—In Singhbhum district, talc-magnesite rocks carrying streaks and stringers of magnesite occur on Pathar Pahar hill near Bhitar Dari (22°42′:86°11′), c. 7 miles from Jamshedpur. The deposit is fairly extensive, the reserves up to a depth of 50 ft. being estimated at 6 million tons (Thiagarajan, *Indian Miner.*, 1958, **12,** 208).

Gujarat—In the former Idar state, magnesite (breunnerite, containing 5–7% ferrous carbonate) occurs in small quantities in association with steatite near Dev Mori (23°39′:73°28′) and Kokapur (23°31′:73°27′) (Roy, 1951, 140 ; Coggin Brown & Dey, 404).

Kashmir—Magnesite occurs in serpentinous rock running east-west along the Kargil-Leh road, half a mile S.-S.E. of Shargol. Details are not available.

Madras—Extensive deposits of magnesite occur in Salem district. The Chalk hills deposit covers an area of 7 sq. miles and extends from the vicinity of Salem town to the foot of Shevaroy hills. The deposit consists of two intrusive masses (150-200 ft. high) of ultrabasic rock (dunites), in which magnesite occurs as a network of irregular veins. Some of the veins are 3 ft. or more in thickness, but the average thickness is only a few inches ; mineralised veins form 6–10% of the whole mass. The region containing the deposit is separated into northern and southern sectors by a tongue of hornblende and biotite gneisses forming the Karangaradu hill. The magnesite-bearing area in

the northern sector covers 4.4 sq. miles and that in the southern sector, 1.1 sq. miles. The total reserves, up to a depth of 100 ft., are estimated at 82.5 million tons. The magnesite is of high grade, the $MgCO_3$ content generally varies from 95 to 97%; picked samples contain 99%. Table 3 gives the analyses of samples from Chalk hills area (Coggin Brown & Dey, 405; Aiyengar, *Bull. geol. Surv. India, Ser. A*, No. 6, 1953, 12).

Magnesite deposits also occur near Siranganur (11°44′:78°46′30″), Sirappalli (11°12′:77°57′30″ and Chettipatti (11°33′30″:77°47′) in Salem district. North of Siranganur village, *c.* 18 miles west of Salem Junction, magnesite occurs over an area of 6 furlongs long × 200–400 yd. wide. The reserves, up to a depth of 50 ft., are estimated at 105,000 tons. About 5 furlongs west of Sirappalli, a deposit (estimated reserves up to 50 ft. depth; 325,000 tons) has been located in a low ridge. The reserves of magnesite near Chettipatti are estimated at 50,000 tons within a depth of 50 ft.

Magnesite occurrences have also been found near Siddharkovil (11°37′30″:78°1′45″), Kundamalai (11°43′:77°51′), Valaiyappatti (11°7′24″:78°13′48″), Jangamanayakkanpatti (11°12′:78°02′), Villiyappanpatti (11°9′20″:78°6′), Puliyampatti (11°9′20″:78°5′45″), Kuppampalaiyam (11°10′30″:78°12′45″), Ariyurpatti (11°13′30″:78°0′20″), Valasiramani (11°7′36″:78°21′36″), Koneripatti (11°11′24″:78°27′), Tandakavundanur (11°33′:78°23′), Tiruppangili (10°56′15″:78°38′45″), Thevur (11°31′30″:77°45′30″), Kanjanur (12°16′:78°28′), Thammampatti (11°26′30″:78°29′) and a few other localities in Salem and Tiruchirapalli districts (Aiyengar, *Bull. geol. Surv. India, Ser. A*, No. 6, 1953, 21; Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 201).

In Coimbatore district, small occurrences of magnesite have been reported near Uttamapalaiyam (11°2′30″:77°38′) and Sikkampalaiyam (11°5′45″:77°37′45″) [Narayanaswami, *Rec. geol. Surv. India*, 1950, **83**(1), 149].

Mysore—In Mysore district, magnesite occurs in

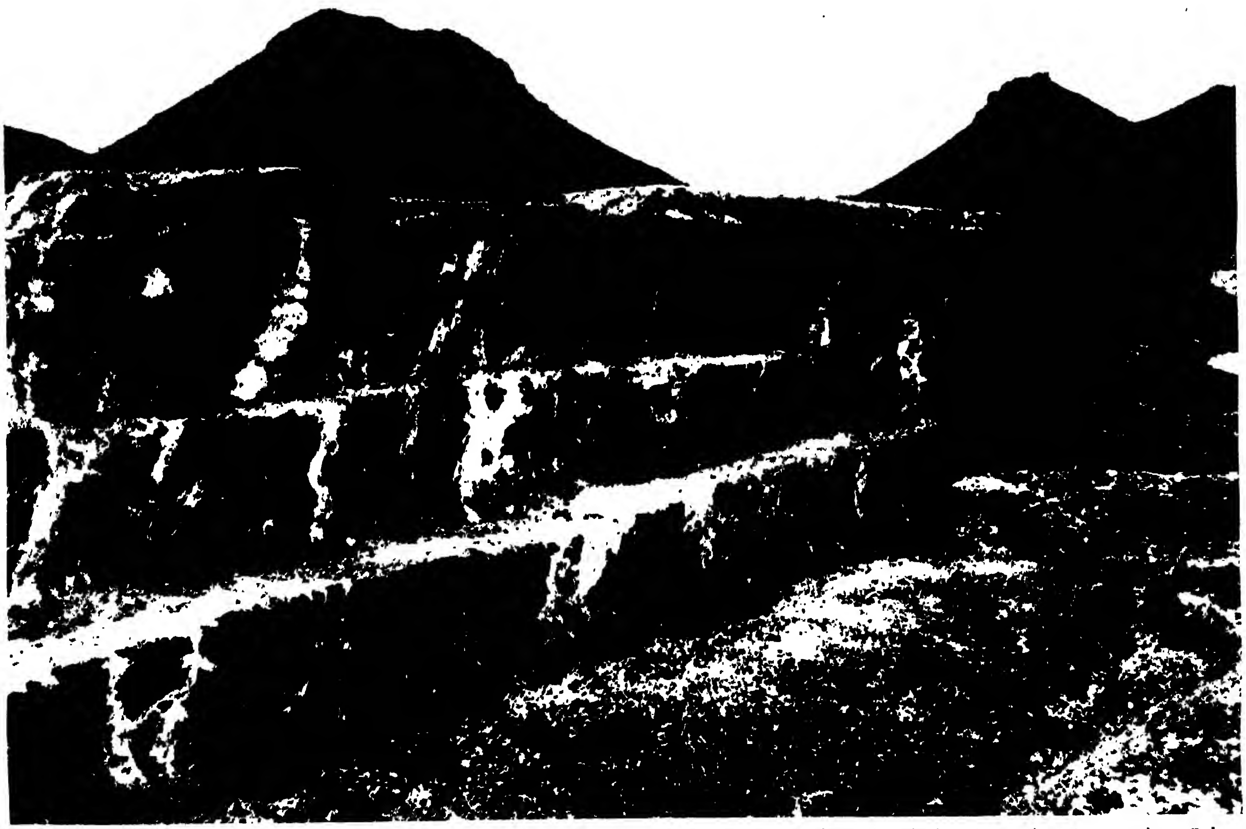


Photo: Dalmia Magnesite Corporation, Salem

FIG. 78. VEINS OF MAGNESITE IN CHALK HILLS, SALEM

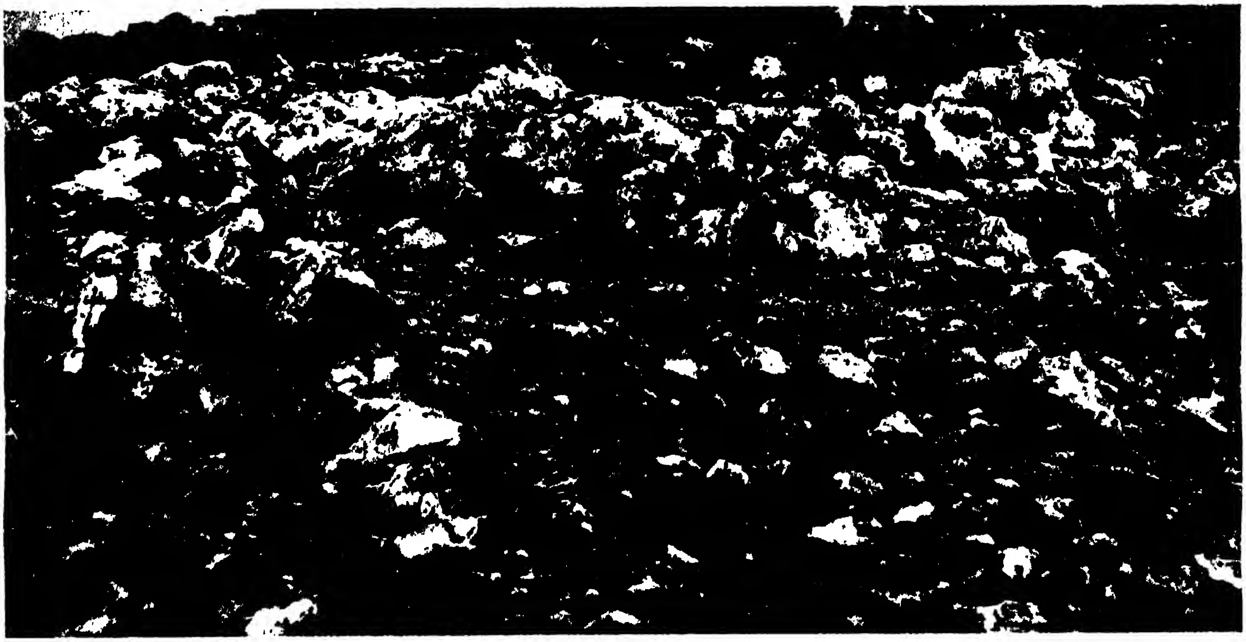


Photo : Dalmia Magnesite Corporation, Salem

FIG. 79. OUTCROP OF MAGNESITE IN CHALK HILLS, SALEM

patches, *c.* 15 miles south-west of Mysore city, at Dodkanya, Uttanahalli, Solepur, Kadakola, Chikkattur, Tallur, Sindhuvalli, Chattanhalli, Gorur, Dodkattur, Mavinhalli, Kupya and Yelwal. In Hassan district, poorer deposits of magnesite occur near Holenarsipur, Sunnakal, Hosur, Dodkadnur, Kabbur, Idegondanahalli and Hardnur.

The more important deposits are located at Dodkanya, Dodkattur and Solepur. The Dodkanya deposit covers an area of 147 acres and is being worked by the *Tata Iron & Steel Co. Ltd.* The Dodkattur area contains *c.* 20,000 tons of magnesite of fairly good quality (Aiyengar, *Bull. geol. Surv. India, Ser. A*, No. 6, 1953, 8).

Magnesite deposits also occur near Daroji (15°15′30″ : 76°40′) in Bellary district and near Seringala (12°22′30″ : 75°31′) and Fraserpet (12°27′ : 75°58′) in Coorg (Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 199).

Rajasthan In Ajmer Merwara, magnesite occurs in small quantities near Sendra (26°5′ : 74°12′), Kala Danta (26°2′ : 74°13′), Kundal (26°0′ : 74°11′) and a few other localities. Sizeable deposits are found in the western part of the former Dungarpur state ; breunnerite has been reported in adjoining tracts. In Jodhpur division, magnesite occurs in small quantities near Patan (26°13′ : 74°14′) [Roy, *Mem. geol. Surv. India*, 1959, **86**, 224 ; Karunakaran, *Rec. geol. Surv. India*, 1958, **88**(1), 126 ; Coggin Brown & Dey, 404].

Uttar Pradesh -In Almora district, magnesite of good quality (MgO, 40%) occurs as narrow bands of variable thickness in massive dolomite between Someshwar and Bageshwar, near Agar (29°48′ : 79°41′), Chhauna (29°47′ : 79°43′), Dewaldhar (29°47′ 30″ : 79°55′), Chhani (29°47′ : 79°47′) and Nail (29°46′ : 79°47′). The Agar-Chhauna deposit, running along the Someshwar–Bageshwar track, is fairly extensive ; the belt is composed of two bands, 20–30 ft. thick, and covers a distance of *c.* 2 miles from east of Agar through Girechchina (29°48′ : 79°42′). Near Dewaldhar, magnesite occurs in two outcrops, one east of the locality and the other *c.* 1 mile S.-S.W. of Chaugaon China (29°47′30″ : 79°46′) : another outcrop, about 1.5 miles long, containing considerable reserves has recently been located. Detailed prospecting and proving operations undertaken since March 1956 in the 3 sectors of Someshwar–Bageshwar region viz. (*i*) the western or Agar Girechchina sector, (*ii*) the eastern or Girechchina-Chhauna sector, and (*iii*) the Dewaldhar sector, have shown that the first sector alone contains *c.* 2.30 million tons of average grade magnesite (MgO, 40.8–43.1%) and 1.05 million tons of low grade magnesite (MgO, 29.5–33.7%) ; the reserves in all the three sectors put together have been estimated

at 10 million tons of average grade magnesite (*Indian Minerals Yearbook*, Indian Bureau of Mines, 1959, 212).

Sixty miles east at Almora town, magnesite, associated with talcose material, occurs in dolomitic limestone at Dewal Thal (29°42′:80°12′30″). The deposit is fairly extensive. Crystalline magnesite occurs also at Chandog (29°43′:80°11′), Satsilang (29°37′:80°14′), Phadiari (29°43′:79°54′) and Jakhera.

Considerable reserves of magnesite occur in dolomitic country rock near Doba, Jhiroli, Bhurgaon and Pagnakhol, Bauri (29°44′15″:79°48′30″), Salia (29°43′:79°54′15″), Rafalket (29°37′:80°18′) and Chamagaon (29°37′45″:80°14′13″). The occurrence near Bauri appears to be extensive; *c*. 300 ft. long × 100 ft. wide. Refractory bricks of good quality can be obtained from Doba magnesite [Nath, *Rec. geol. Surv. India*, 1958, **87**(1), 114; Sondhi & Nath, ibid., 1948, **81**(1), 61; Rao *et al.*, *Trans. Indian ceram. Soc.*, 1958, **17**, 67; *Indian Miner.*, 1959, **13**, 168].

Mining and Treatment

In 1959, in all 9 magnesite mines—6 in Madras State and 3 in Mysore State—were in operation in the country. All the mines are worked by open-cast method and usually recover the ore manually; in certain areas mechanical aids, like power winches and pneumatic hammer drills are used. The ore mined from the Chalk hills (Madras State) and Dodkanya or Dodkattur (Mysore State) deposits are of fairly good quality; they are beneficiated by hand dressing and used in the manufacture of firebricks. Sometimes the ores, as mined, are too impure to permit direct utilization of hand dressed ore: they are usually beneficiated by screening or hydraulic separation for removing silica, talc, etc. Further purification can be effected by froth flotation, using sodium silicate in the presence of acids or acid salts as depressors and oleates or oleic acid, as collectors. In some cases, reversed flotation has been applied and the gangue is floated, after the addition of creosote oil (Kirk & Othmer, VIII, 597).

The Chalk hills deposits have been exploited since 1902 by the *Magnesite Syndicate Ltd.*, Suramangalam; other lease holders are: the *Salem Magnesite Ltd.*, Bombay and the *Dalmia Magnesite Corporation*, Salem. The Mysore deposits are exploited by the *Tata Iron & Steel Co. Ltd.*

Photo: Dalmia Magnesite Corporation, Salem

FIG. 80. ORE DRESSING OF MAGNESITE

Properties and Uses

Magnesite dissociates on heating into magnesia and carbon dioxide. When calcined in a shaft or rotary kiln at 800–850°, it is converted to 'caustic magnesia' which, owing to incomplete dissociation, still contains 1–2% carbon dioxide as carbonate. When the mineral is calcined at 1,600–1,800°, carbon dioxide is expelled completely and a dense product, 'dead-burnt magnesia', is obtained. Fused magnesia is obtained by heating magnesite in an electric furnace at 2,500–3,000°; it is resistant to the action of molten metals, basic slags and fluxes at high temperatures.

Magnesite is used largely in the manufacture of refractory bricks and as monolithic linings for open-hearth steel furnaces, smelting and refinery furnaces for lead, copper and nickel, and rotary kilns for the manufacture of portland cement. Refractory bricks are made by grinding dead-burnt magnesia (and chrome ore) with water in a pan mill and pressing it into shape in moulds. Processes for the production of basic refractories used in lining basic open-hearth furnaces have been developed by the National Metallurgical Laboratory, Jamshedpur; caustic magnesia, magnesium chloride and graded dead-burnt magnesia or a mixture of dead-burnt magnesia and chromite are the ingredients employed.

Fused magnesia is employed in the form of moulded vessels and as compressed material for covering resistance elements in the melting of lead, tin, type metal, etc.

Caustic magnesia is a hygroscopic material similar to quicklime; if calcined at much higher temperatures, the material loses its cementing property. Caustic magnesia is used in the manufacture of Sorel (magnesium oxychloride) cement and as a filler in paper, paint and rubber industries. It forms the starting material for the production of magnesium sulphate, chloride, silicate and other commercial magnesium salts. Magnesium metal is obtained by the electrolysis of anhydrous or partially hydrated magnesium chloride.

Sorel cement is obtained by treating powdered caustic magnesia with magnesium chloride solution. The magnesia required for this purpose should contain not less than 90% MgO and *c.* 2.5% free CaO; the concentration of iron oxide, alumina and silica should be very low. Sorel cement is hard-setting with high compressive strength, and dimensional changes in setting are very slight. These properties are taken advantage of in the use of the cement for statuary and decorative mouldings. It is used also in adhesive compositions, artificial stones, flooring tiles for use in railway carriages, kitchens, bath rooms, etc. and roofing and insulating compositions, and as a binder for fuel briquettes and refractory bricks.

Caustic magnesia and dead-burnt magnesia are produced by *Magnesite Syndicate Ltd.* at Salem. *Dalmia Magnesite Corporation* have installed in 1959 a plant for the manufacture of dead-burnt magnesia at Chettichavadi Jaghir near Salem. Table 4 gives the analyses of caustic and dead-burnt magnesia produced by the *Magnesite Syndicate Ltd.* Magnesite bricks for use in steel furnaces are produced by *Tata Iron & Steel Co. Ltd.*, Jamshedpur and *Burn & Co. Ltd.*, Calcutta. The *Tata Iron & Steel Co. Ltd.* is setting up a new refractory unit, at a cost of Rs. 38.8 million, in collaboration with *Didier-Werkel* of West Germany. This unit would make chrome-magnesite bricks, fire-clay bricks and silica bricks; the unit when completed will require *c.* 10,000 tons of calcined magnesite per annum. The *Burn & Co. Ltd* are likely to set up shortly a factory at Salem for the manufacture of magnesite and chrome-magnesite refractory bricks utilizing local magnesite. A new unit, being set up by *Orissa Cement Ltd.*, at Rajgangpur would soon commence manufacture of magnesite monochrome and chrome-magnesite bricks; it will consume 12,000–15,000 tons of dead burnt magnesia per annum. The composition of magnesite used in the manufacture of bricks is as follows: MgO, 46.3–46.7; SiO_2, 0.9–1.2; Al_2O_3, $\ngtr$0.14; Fe_2O_3, 0.28–0.72; and CaO, $\ngtr$1. Chrome-magnesite bricks are produced at present by *Belphar Refractories*, Orissa using calcined magnesite [Aiyengar, *Bull. geol. Surv. India, Ser.* A, No. 6, 1953, 33; Engineer, *Indian Constr. News*, 1959, **8**(8), 109; *Res. & Ind.*, 1960, **5**, 109; *Indian Minerals Yearbook*, Indian Bureau of Mines, 1959, 213].

TABLE 4—ANALYSES OF CAUSTIC MAGNESIA AND DEAD-BURNT MAGNESIA FROM CHALK HILLS AREA, SALEM*

	Caustic magnesia %	Dead-burnt magnesia %
Silica	3.39	3.59
Iron oxide & alumina	0.14	1.07
Lime	1.48	1.02
Magnesia	93.18	92.13
Loss on ignition	1.81	0.15

* Aiyengar, *Bull. geol. Surv. India, Ser. A*, No. 6, 1953, 34.

TABLE 5—PRODUCTION OF MAGNESITE DURING 1948-60

(Qty in metric tons; val. in thousand Rs.)

	Qty	Val.
1948 52 (av.)	80,930	1,356
1953	94,237	1,825
1954	71,639	1,453
1955	58,432	1,256
1956	93,183	1,846
1957	90,312	1,759
1958	104,236	1,793
1959	157,967	2,435
1960†	156,331	2,683

† Provisional.

TABLE 6—STATE-WISE PRODUCTION OF MAGNESITE DURING 1956-60

(Qty in metric tons; val. in thousand Rs.)

	Madras (Salem)		Mysore		Total	
	Qty	Val.	Qty	Val.	Qty	Val.
1956	93,183	1,846	..	..	93,183	1,846
1957	88,924	1,681	1,388	114	90,312	1,795
1958	100,558	1,610	3,678	183	104,236	1,793
1959	154,281	2,282	3,686	153	157,967	2,435
1960†	151,886	2,404	4,445	279	156,331	2,683

† Provisional.

TABLE 7—EXPORTS OF MAGNESITE

(Qty in metric tons; Val. in thousand Rs.)

Year	Qty	Val.
1948/49-1952/53 (av.)	34,312	3,334
1953 54	40,029	4,224
1954 55	23,384	3,585
1955 56	26,904	4,168
1956 (April to Dec.)	26,100	4,608
1957	21,786	3,649
1958	19,899	3,207
1959	27,988	4,715
1960-61	29,537	6,367

PRODUCTION AND TRADE

Tables 5 and 6 give the total and state-wise production of magnesite in India during recent years. The bulk of the production is calcined and exported (Table 7). The estimated domestic consumption of magnesite in refractory and chemical industries was 25,000 tons in 1959 as compared to 23,000 tons in 1958.

The price of crude magnesite (MgO, 45.5%) was Rs. 44.30 per metric ton f.o.b. Madras in 1960. The prices of top grade, first grade and service grade calcined magnesite were respectively Rs. 249.70, Rs. 208.20 and Rs. 153.41 per ton f.o.b. Madras. Bulk price of dead-burnt magnesite in 1960 was Rs. 211.60 per metric ton.

Magnetite — *see* **Iron Ores**

MAGNOLIA Linn. (*Magnoliaceae*)

A genus of trees or shrubs distributed in North and Central America, West Indies, South-East Asia, China and Japan. About 10 species are found in India and some exotics are cultivated for ornament.

Magnolias thrive best in moderately rich, moist and porous soil, and are suitable for medium to high elevations; at low elevations they remain stunted. Propagation is done by seeds, green cuttings with heel or by layering; some are propagated by grafting (Gopalaswamiengar, 279; Johnstone, G. H., 24-33).

M. campbellii Hook. f. & Thoms.

D.E.P., V, 107; Fl. Br. Ind., I, 41; Johnstone, G. H., Pl. 2 & 3.

NEPAL—*Lal champ, ghoge champ;* LEPCHA—*Sigumgrip, gok;* BHUTAN—*Pendder, patagari.*

A handsome deciduous tree, 18-24 m. in height and 3.0-3.6 m. in girth with a bole 9-15 m. long, found in eastern Himalayas at altitudes of 2,100-3,000 m. and in Manipur; it is cultivated in Nilgiris. Bark dark coloured, almost black on branches; leaves elliptic-ovate or oblong; flowers pink or white, 15-25 cm. diam.; fruits 15-20 cm. long.

The tree is reported to be useful for filling up blanks in tea plantations at high elevations, where the choice of species is limited. The wood is yellowish white, soft and light (wt., 25 lb./cu.ft.) with firm, compact, lustrous grain. It is used for planking and tea boxes; it presents a beautiful colour in panelling (Gamble, 9-10; Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 142; Howard, 316).

M. grandiflora Linn. BULL BAY

Benthall, 3; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(2), suppl., 12, Fig. 3.

HINDI—*Andachampa, him champa.*

A handsome evergeen pyramidal tree, up to 24 m. high, native of N. America, cultivated in Indian gardens; it does well up to an altitude of 2,100 m. in the Himalayas and in Nilgiris. Bark smooth, grey; leaves large, obovate-oblong or elliptic, glossy above, rusty pubescent beneath, firmly coriaceous; flowers cup-shaped, 15–20 cm. diam., waxy white, fragrant; fruits ovoid, rusty-tomentose; seeds brilliant red.

Most parts of the plant contain volatile oils. The perfume of the flowers (Magnolia Oil) resembles ylang-ylang backed up with orange blossom. Steam-distillation of flowers (from Jammu) gave 0.12% of a volatile oil ($n^{20°}$, 1.478) with a pleasant odour characteristic of the flowers. Extraction of fresh flowers with petroleum ether yields (c. 0.15%) a greenish yellow, brittle concrete (m.p. 58–60°; acid val., 28; ester val., 84) containing *c.* 10% of a steam-distillable, semi-solid volatile oil. Magnolia oil is not extracted on a commercial scale; magnolia perfumes of commerce are mostly artificial [Poucher, II, 166, 168; Handa *et al.*, *J. sci. industr. Res.*, 1957, **16A**(5), suppl., 26; Naves & Mazuyer, 215–16].

A volatile oil with an agreeable aroma is obtained by the steam-distillation of leaves in 0.1–0.15% yield; it becomes viscous on exposure to air. The oil contains phenols (3%), carbonyl compounds (4%), cineole, and a mixture of sesquiterpenes and undetermined oxygenated compounds (Guenther, V, 383).

Analysis of seeds gave the following values: moisture, 6.94; crude protein, 9.07; ether extr., 46.23; crude fibre, 19.10; N-free extr., 16.70; and ash, 1.96%; glucose, tannin, two carotenoids, phytosterol and an unidentified reddish brown substance are present. A light yellow volatile oil with a pleasant aromatic odour is obtained by steam-distillation. Extraction with petroleum ether yields a fatty oil with the following characteristics: $d_{25°}^{25°}$, 0.9652; $n_D^{25°}$, 1.43; iod. val., 89.5; sap. val., 182.5; and unsapon. matter, 2.83%. It contains 20.20% saturated acids (mostly palmitic) and 72.63% unsaturated acids (oleic and linoleic, the former predominating). The oil is suitable for use in soaps and lotions (*Chem. Abstr.*, 1934, **28,** 6007; 1938, **32,** 7669).

The bark of the tree is considered as stimulant, aromatic and tonic; it is reported to be used for malaria and rheumatism. It contains two alkaloids, salicifoline ($C_{12}H_{21}O_3N$) and magnoflorine; the iodide of latter is identical with corytuberine methyl iodide ($C_{19}H_{21}O_4N.CH_3I$). Salicifoline and another quaternary alkaloid, candicine ($C_{11}H_{19}O_2N$), have been isolated from the roots. The leaves contain 11.8 mg./kg. of carotenes (α-carotene, 20% of the total carotenes). Extracts of the plant cause a rapid fall in blood pressure when administered intravenously to experimental animals; they have no toxic effects. The plant contains rutin (Burkill, II, 1392–93; *Chem. Abstr.*, 1956, **50,** 6475, 7117; Heilbron & Bunbury, I, 609; Deuel, I, 519; *J. Pharm., Lond.*, 1954, **6,** 84; Krewson & Naghski, *Amer. J. Pharm.*, 1953, **125,** 190).

M. grandiflora is the source of considerable lumber in America, known in the trade as Magnolia. It is greenish grey in colour and has the consistency of maple; it is used as a substitute for *Liriodendron tulipifera.* The wood is suitable for the production of unbleached pulps (Record & Hess, 345; *Chem. Abstr.*, 1959, **53,** 9663).

M. pterocarpa Roxb. syn. *M. sphenocarpa* Roxb. (Fl. Br. Ind.)

D.E.P., V, 107; Fl. Br. Ind., I, 41; King, *Ann. R. bot. Gdn Calcutta*, 1891, **3,** 207, Pl. 53.

BENG.—*Dulichamp, anda champa.*

NEPAL—*Patpate*; ASSAM—*Thouthua, baramp thuri-sopa*; LAKHIMPUR—*Balom turi.*

A moderate-sized to large evergreen tree with a rounded crown, found in eastern Himalayas and Assam up to an altitude of 900 m.; it is also cultivated in gardens. Leaves elliptic, oblong or obovate, coriaceous; flowers white, fragrant; fruit 20–40 cm. long; seeds orange-coloured.

Tender stipules and fleshy buds of the plant possess a pleasant pungent flavour and are chewed in Assam to blacken gums and teeth. The wood is white, even grained, soft, fairly light and strong. It is suitable for tea boxes; it may be used for planking but does not bear exposure to moisture. The wood is used as fuel in Lakhimpur [Gamble, 9; Benthall, 5; Carter & Carter, *Rec. bot. Surv. India*, 1921, **6**(9), 374; Fl. Assam, I, 13].

M. denudata Desr. syn. *M. conspicua* Salisb. is a small tree native of China, reported to be cultivated in Calcutta. Its bitter aromatic buds and seeds are considered medicinal. In China, the buds are used in seasoning rice. The bark contains two water soluble alkaloids, salicifoline and magnocurarine ($C_{19}H_{25}O_4N.½H_2O$, m.p. 200°); the latter is identical with N-methyl coclaurine methohydroxide and

has a curare-like action on frogs. The roots contain magnoflorine (Firminger, 629; Burkill, II, 1392; Encyclopaedia Britannica, XIV, 671; *Chem. Abstr.*, 1953, **47,** 12288, 10128; 1952, **46,** 5059; 1957, **51,** 2823).

M. kobus DC. is a small tree native of Japan, reported to be cultivated in the Lloyd Botanic Garden, Darjeeling. A volatile oil (Kabushi Oil) is distilled from the leaves and twigs in Japan. It contains citral (*c.* 15%), anethole (16%), cineole, eugenol and probably methyl chavicol and pinene. The flowers contain rutin (0.05%) and the bark, salicifoline [Biswas, *Rec. bot. Surv. India,* 1940, **5**(5), 434; Gildemeister & Hoffmann, II, 373; *Biol. Abstr.*, 1956, **30,** 1441; *Chem. Abstr.*, 1949, **43,** 8450; 1954, **48,** 2639].

M. obovata Thunb. syn. *M. hypoleuca* Sieb. & Zucc. is a large handsome tree native of Japan, reported to be cultivated in the Lloyd Botanic Garden, Darjeeling. The wood of this species is used as a substitute for boxwood and for lacquer ware in Japan. The bark contains magnocurarine (0.015%), magnolol ($C_{18}H_{18}O_2$, m.p. 103°) and machilol ($C_{15}H_{26}O$, m.p. 83°). The flesh of the fruit and seed kernels contain respectively 35.3% and 59.6% fatty oil. Rutin is present in the flowers (Biswas, loc. cit.; Burkill, II, 1393; Bailey, 1947, II, 1964; *Chem. Abstr.*, 1952, **46,** 5059; 1944, **38,** 4010; 1930, **24,** 3505; Wehmer, suppl., 124; Eckey, 402–03).

Mahogany, Swamp — *see* **Eucalyptus**

Mahogany Tree — *see* **Swietenia**

MAHONIA Nutt. (*Berberidaceae*)

A genus of evergreen shrubs, rarely small trees, distributed in Asia and North and Central America. Fifteen species occur in India*, of which fourteen are found in the sub-temperate Himalayas; one is confined to the hills of S. India.

Mahonias are sometimes grown in gardens for their handsome foliage and flowers. They prefer a humid soil and need to be protected from strong wind and hot sun. They are propagated by seeds, suckers, cuttings or by layers (Bailey, 1947, II, 1970).

The Himalayan species of *Mahonia* are reported to be used in the same manner as *Berberis* (q.v.). Several species contain *iso*quinoline alkaloids (Table 1) similar to those present in *Berberis*. The alkaloids identified are: berberine ($C_{20}H_{19}O_5N$, m.p. 205–07° decomp.), oxyacanthine ($C_{37}H_{40}O_6N_2$, m.p. 208–09°), palmatine ($C_{21}H_{23}O_5N$), jatrorrhizine ($C_{20}H_{21}O_5N$), berbamine ($C_{37}H_{40}O_6N_2$, m.p. 170–72°), umbellatine ($C_{21}H_{25}O_5N$, m.p. 206–07° decomp.) and neprotine ($C_{14}H_{23}O_6N$, decomp. above 200°). Umbellatine is reported to be identical with berberine, and neprotine with jatrorrhizine. Berberine is moderately toxic to large animals; it has been used in the treatment of oriental sore. Palmatine and jatrorrhizine paralyse the central nervous system and oxyacanthine affects the respiratory system [Chatterjee, *Rec. bot. Surv. India*, 1953, **16** (2), 55, 61, 67–68; Govindachari *et al.*, *Proc. Indian Acad. Sci.*, 1958, **47A,** 41; Wlth India —Raw Materials, I, 177; Henry, 345].

M. acanthifolia G. Don syn. *Berberis nepalensis* Spreng. in part

Fl. Br. Ind., I, 109; Chatterjee, *Rec. bot. Surv. India*, 1953, **16** (2), 39, Fig.

Nepal—*Kesari, chutro.*

An evergreen, robust, arborescent shrub found in Nepal, Sikkim, North Bengal and Naga hill ascending up to 2,400 m. Leaves pinnate: leaflets oblong or oblong-ovate; flowers yellow, in dense fascicled racemes: berries ovoid, blue-black, edible when ripe (Cowan & Cowan, 14).

The wood is bright yellow, hard and heavy; it is used for making handles of knives and *kukries*. The alkaloids found in the roots of the plant are listed in Table 1 (Cowan & Cowan, 14).

M. napaulensis DC. syn. *Berberis nepalensis* Spreng. in part

D.E.P., I, 446; Fl. Br. Ind., I, 109; Chatterjee, *Rec. bot. Surv. India*, 1953, **16** (2), 36.

Nepal—*Chatri.*

A tall evergreen shrub found in Nepal at altitudes of 1,200–2,100 m. Leaves pinnate: leaflets oblong, broadly oblong or ovate; flowers small, yellow, in erect fascicled racemes: berries ovoid, blue-black. The plant flowers in March and flowering continues up to the end of the rainy season. In Darjeeling, where the plant has been reported to occur, flowering has not been observed and the growth of the plant is stunted.

The roots, stem bark and wood contain the alkaloids umbellatine and neprotine (Table 1): the maximum yield of total alkaloids is obtained from old plants collected in winter (roots, 0.498; stem bark, 0.377; and wood, 0.261%) (Chatterjee, *J. Amer. pharm. Ass., sci. Edn*, 1944, **33,** 205, 210).

* Until recently, *M. napaulensis* DC. syn. *Berberis nepalensis* Spreng. was considered to be the only species found in India. According to the latest revision, *M. napaulensis* has been split up into a number of distinct species.

TABLE 1—THE ALKALOIDS OF MAHONIA SPP.

Species	Distribution	Plant part	Alkaloids
M. acanthifolia G. Don[1]	Nepal, Sikkim, North Bengal & Naga hills	Root	Oxyacanthine (trace), berberine (0.5%), neprotine (0.007%), palmatine (0.07%) & jatrorrhizine (0.138%)
M. borealis Takeda[2]	N.W. India & Lushai hills	Root	Oxyacanthine (trace), berberine (0.16%), neprotine (0.311%), palmatine (0.031%) & jatrorrhizine (0.038%)
M. griffithii Takeda[3]	Bhutan	Bark	Oxyacanthine (trace), berberine (0.3%), neprotine (0.001%), berbamine & palmatine (traces)
M. leschenaultii Takeda[4]	Hills of S. India	Root	Oxyacanthine (trace), berberine (1.02%), neprotine (0.011%), palmatine (0.075%) & jatrorrhizine (0.031%)
M. manipurensis Takeda[4]	Manipur	Root	Oxyacanthine, berberine, neprotine & jatrorrhizine (traces)
M. napaulensis DC.[5]	Nepal	Root	Umbellatine (0.48%) & neprotine (0.02%)
M. sikkimensis Takeda[4]	Sikkim	Stem bark	Oxyacanthine (trace), berberine (0.455%) & neprotine (0.0009%)
M. simonsii Takeda[2]	Khasi hills	Root	Oxyacanthine (trace), berberine (0.021%), neprotine (0.27%), palmatine (0.024%) & jatrorrhizine (0.02%)

[1] Chatterjee & Guha, *J. Amer. pharm. Ass., sci. Edn*, 1950, **39**, 577 ; [2] Chatterjee *et al.*, ibid., 1951, **40**, 36 ; [3] Chatterjee & Guha, ibid., 1950, **39**, 181 ; [4] Chatterjee & Guha, ibid., 1951, **40**, 229 ; [5] Chatterjee, ibid., 1944, **33**, 210.

The roots yield a yellow dye. The berries are eaten ; they are considered diuretic and demulcent. The well known drug *Rasanjana* or *Rasaut*, prepared from certain species of *Berberis* (q.v.), is also obtained from this plant. The wood is hard and bright yellow ; it is used for inlaying (Perkin & Everest, 631 ; Kirt. & Basu, I, 106 ; Chatterjee, *Lloydia*, 1949, **12**, 178).

M. borealis Takeda (Lushai –*Pualeng*) is a very variable plant with oblong or oblong-lanceolate leaflets, yellow flowers in dense fascicled racemes and sub-globose blue-black berries found in North-west India and Lushai hills (Assam) at altitudes of 1,500–2,100 m. The sap of the plant contains a yellow colouring matter. Five alkaloids have been isolated from the roots (Table 1) [Chatterjee, *Rec. bot. Surv. India*, 1953, **16** (2), 41 ; Fischer, ibid., 1938, **12** (2), 79].

M. sikkimensis Takeda is a shrub found in Sikkim at altitude of 2,100 m. It is put to similar uses as *M. acanthifolia* and *M. napaulensis*. Three alkaloids have been isolated from the stem bark of the plant (Table 1) [Chatterjee, *Rec. bot. Surv. India*, 1953, **16** (2), 40].

Mahua Tree — *see* **Madhuca**

Maidenhair Fern — *see* **Adiantum**

Maidenhair Tree — *see* **Ginkgo**

Maize — *see* **Zea**

MAJORANA Moench (*Labiatae*)

A small genus of perennial herbs or undershrubs distributed in the Mediterranean region. One exotic species is cultivated in Indian gardens as a savory plant.

M. hortensis Moench syn. *Origanum majorana* Linn. Sweet Marjoram

D.E.P., V, 493 ; Fl. Br. Ind., IV, 648 ; Bailey, 1947, II, 2406 ; Kirt. & Basu, Pl. 759 B.

Hindi –*Murwa* ; Beng.—*Murru* ; Tam. –*Marru*, *maruvu* ; Kan.—*Maruga* ; Mal.—*Maruvamu*.

Kumaon—*Bantulsi* ; Deccan –*Murwa*.

An aromatic, branched perennial, 30–60 cm. high, native of southern Europe, North Africa and Asia Minor, commonly grown in Indian gardens : it is particularly suited for hill stations. Leaves oblong-ovate ; flowers small, whitish or purplish, in terminal clusters ; seeds minute, oval, dark brown (Gopalaswamiengar, 560).

M. hortensis, though a perennial, is treated as an annual under cultivation. It grows in any well-drained fertile garden loam. It is propagated by seeds and cuttings. Seeds are sown in the plains in October and in the hills from March to the middle of June. Seeds are sown in pots and seedlings, when large enough to handle, are transplanted in the field 8–10 in. apart in rows which are spaced 12 in. apart. Propagation by cuttings is sometimes done at higher elevations.

FIG. 81. MAJORANA HORTENSIS—FLOWERING BRANCH

The crop is ready for harvesting in *c.* 3½ months. The tops are cut when the plants are coming into flower and dried in the shade. The volatile oil content of leaves is maximum when the plant is harvested before seed formation (Sievers, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1999, 1948, 68 ; Gollan, 47 ; Gopalaswamiengar, 560 ; Guenther, III, 520).

Sweet marjoram is characterized by a strong, spicy and pleasant odour and flavour. Analysis of the dry herb gave the following values: water, 7.61 ; protein, 14.31 ; fixed oil, 5.60 ; volatile oil, 1.72 ; pentosans, 7.68 ; fibre, 22.06 ; and ash, 9.69%. Tannin, a bitter substance and ursolic acid (0.21% in tops ; 0.05% in stem) are present (Guenther, III, 520 ; Winton & Winton, IV, 237 ; Wehmer, II, 1051 ; *Chem. Abstr.*, 1953, **47**, 7164).

The leaves of the plant are used fresh or dried and highly esteemed as a condiment for seasoning food ; they are used also as a poultry-seasoner. Fresh leaves are employed as garnish and incorporated in salads ; they are used also for flavouring vinegar. Dried flowering tops are used for sachets and potpouri. The aromatic seeds are used in confectionery and French confitures (Muenscher & Rice, 90 ; Hill, 463 ; Youngken, 719 ; Guenther, III, 520).

Steam-distillation of the leaves and flowering heads yields a volatile oil, known in the trade as Oil of Sweet Marjoram (yield from fresh flowering herb, 0.3–0.4% ; dry herb, 0.7–3.5%). The oil is colourless or pale yellow to yellow-green, with a tenacious odour reminiscent of nutmeg and mint. A sample of Indian oil (from Delhi) had the following physico-chemical properties: sp. gr.$^{15°}$, 0.9346 ; $n^{15°}$, 1.5062 ; $[\alpha]_D^{20°}$, +40.25° ; acid val., 4.8 ; sap. val., 8.32 ; sap. val. (after acetylation), 128.4 ; and phenol content, 47.7%. The oil consisted of carvacrol (36.4%), eugenol (6.7%), chavicol (4.6%), *d*-linalool (30.6%), methyl-chavicol (3.2%), *d*-α-terpineol (4.8%) and caryophyllene (7.6%). Oils of European origin differ considerably from the Indian oil and have usually the following ranges of characteristics: sp. gr.$^{15°}_{15°}$, 0.894 0.910 ; $n^{20°}$, 1.470–1.476 ; $[\alpha]_D$, +15° to +25° ; acid val., up to 1.5 ; ester val., 10.0–38.0 ; ester val. (after acetylation), 41.0–78.0 ; sol. in 1–2 vols. and more of 80% alcohol. They contain *c.* 40% terpenes (mainly terpinene) but are free from phenols ; *d*-α-terpineol and terpinenol are also present. Sweet marjoram oil is often confused in commerce with thyme oil (from *Thymus* spp.) and origanum oil (from *Origanum* spp.) (Guenther, III, 519–24 ; Dutt, *Indian Soap J.*, 1955–56, **21**, 12 ; Poucher, I, 263–64).

The oil is employed to a small extent in high grade flavour preparations and perfumes, and in soap and liqueur industries. It is used as an external application for sprains, bruises, stiff and paralytic limbs and toothache, and for hot fomentation in acute diarrhoea (Guenther, III, 526 ; Steinmetz, II, 287 ; Kirt. & Basu, III, 1985).

Sweet marjoram is considered carminative, expectorant and tonic ; leaves and seeds are astringent. An infusion of the plant is used as stimulant, sudorific, emmenagogue and galactagogue ; it is reported to be useful in asthma, hysteria and paralysis (Kirt. & Basu, III, 1985 ; Chopra, 1958, 513 ; Steinmetz, II, 287).

Malabar Blackwood — *see* **Dalbergia**

Malabar Catmint — *see* **Anisomeles**

Malabar Kino — *see* **Pterocarpus**

Malacca Eagle-wood — *see* **Aquilaria**

Malachite — *see* **Copper Ores**

MALACHRA Linn. (*Malvaceae*)

A small genus of herbs or undershrubs distributed chiefly in the warmer regions of America and West Indies. One species, which yields a jute-like fibre, is naturalized in India.

M. capitata Linn.

D.E.P., V, 109; C.P., 755; Fl. Br. Ind., I, 329.

Beng.—*Banbhindi.*

Bombay —*Bhanbhendi, ranbhendi, vilayatibhendi, pardeshibhindo.*

A coarsely hispid herb, sometimes up to 3 m. in height, naturalized in the hotter and damp parts of India. Leaves ovate, cordate or orbicular; flowers in heads, yellow or white; fruit sub-globose, depressed; seeds smooth, brownish black.

M. capitata is a rigid and sturdy plant, mostly occurring as a weed in fields and waste places. It is particularly abundant in some parts of Bombay and Bengal, usually on land liable to be inundated during rains. If cultivated during rains, it requires little attention. Plants should be grown close and protected from high winds (Betrabet & Navalkar, *Indian Text. J.*, 1955–56, **66,** 682).

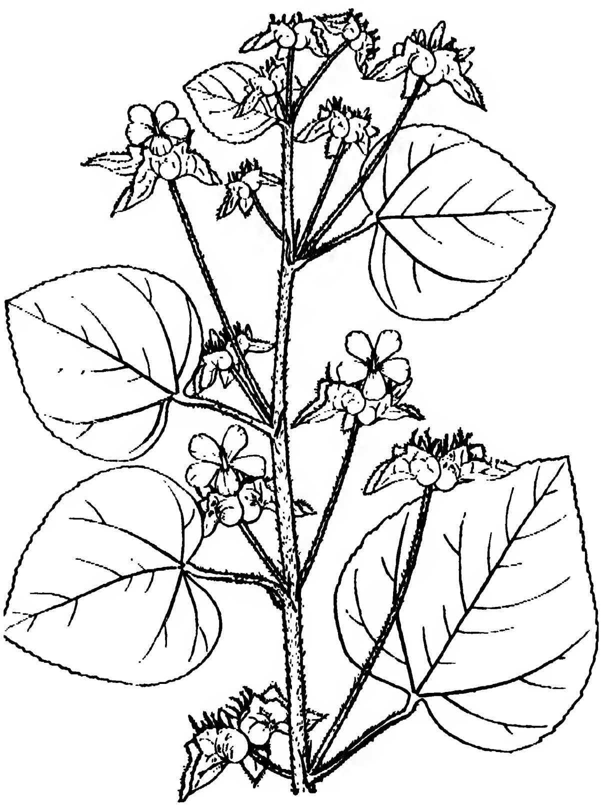


FIG. 82. MALACHRA CAPITATA—FLOWERING BRANCH

The bast yields a fibre resembling jute. For obtaining the fibre, the plants are harvested 3–4 months after planting, roots and leaves are removed and the green stems retted in the same way as jute or sunn hemp in small concrete tanks for 6–8 days. The fibre can be readily separated from retted stems as the plant does not have profuse lateral branches. The yield of fibre is *c.* 11% of the oven-dry material. A yield of 560 lb. of fibre has been reported from an experimental plantation 1,600 sq. yd. in area.

Malachra fibre is almost white, soft and lustrous, somewhat uneven in strength and rough at root ends. It is up to 2 m. or more in length and generally resembles jute in its multicellular structure, long striations, etc.; like jute fibre, it dries with a counter clock-wise twist. The ultimate cells have an average length of 2.1 mm. and a diam. of 16.3μ, giving a length : diameter ratio of 128. As compared to jute, the intrinsic strength (2.12 g./denier) is low and the percentage elongation at break (4.29) is high. The fibre closely resembles jute in chemical composition; analysis of a sample gave the following values: fat & wax, 0.51; cellulose, 88.26; lignin, 10.16; N, 0.167; and ash, 0.762 g./100 g. of oven-dry material (Betrabet & Navalkar, loc. cit.; *Bull. imp. Inst., Lond.*, 1914, **12,** 33).

The fibre is suitable for use in cordage, gunny bags and coarse textiles. It can be spun on jute mill machinery without difficulty; it may be used as a substitute for jute or in admixture with it. It may also be tried for paper making (Harris, 39; Betrabet & Navalkar, loc. cit.).

The plant is mucilaginous and is reported to possess emollient and pectoral properties. The roots are used in embrocations for rheumatism and lumbago and as a febrifuge. The leaves are used as an anthelmintic in Panama (Kirt. & Basu, I, 319; Nadkarni, I, 633).

MALCOLMIA R. Br. (*Cruciferae*)

D.E.P., V, 113; Fl. Br. Ind., I, 146.

A small genus of annual herbs, native of the Mediterranean region. One species, *M. africana* R. Br. (Punjab—*Patthar, chinaka*), is found in Punjab, Kashmir and western Tibet up to an altitude of 3,900 m. The plant grows gregariously in some places. Along with other *Cruciferae*, it affords fodder for goats and sheep.

Male Bamboo — *see* **Dendrocalamus**

Male Fern — *see* **Dryopteris**

MALLOTUS Lour. (*Euphorbiaceae*)

A large genus of trees or shrubs distributed chiefly in the tropical and sub-tropical regions of the Old World. About 20 species are found in India.

M. philippensis Muell. Arg. KAMALA TREE

D.E.P., V, 114; C.P., 755; Fl. Br. Ind., V, 442.

HINDI—*Kamala, sindur, rohini*; BENG. *Kamala*; MAR.—*Shendri*; GUJ.—*Kapilo*; TEL.—*Kunkuma, sinduri, chendiramu*; TAM.—*Kapli, kungumam, kurangumanjanatti*; KAN.—*Kunkumadamara*; MAL.—*Manjana, kuramadakku*; ORIYA—*Sinduri, kunkumo, kapilogundi.*

NEPAL—*Sindure*; LEPCHA—*Puroakung*; ASSAM—*Jorat, losan.*

A shrub or a small, much-branched, evergreen tree with a short and often buttressed bole, found throughout India occasionally ascending to 1,500 m. in the outer Himalayas. Bark thin, grey, somewhat rough; leaves variable, broadly ovate to ovate-oblong or ovate-lanceolate, glabrous above, pubescent with numerous red glands beneath; flowers in spikes, dioecious, small; capsules globose, 3-lobed, 3-valved, 0.75–1.25 cm. diam., densely covered with reddish brown glandular pubescence; seeds sub-globose, black, smooth, *c.* 4 mm. diam.

FIG. 83. MALLOTUS PHILIPPENSIS—FRUITING BRANCH

Kamala tree is widely distributed in northern, central, western and southern India; it is scarce in the Andaman Islands. It is commonly found in sal and certain scrub and mixed forests. In sal forests, it is often gregarious and precedes the appearance of sal, killing out grasses and acting as a nurse to it. In the monsoon or open thorn forests of Bombay State, it is often gregarious. The tree can stand considerable shade and is frost-hardy and drought-resistant. It coppices well.

Natural reproduction takes place by seeds which fall to the ground in the beginning of the hot season and germinate in the ensuing rainy season. The seeds are susceptible to drought and insect attack; where loose bare soil is available, seeds get covered during rains and germination is facilitated. Artificial propagation is done by sowing fresh seeds by about April. Germination is rather uncertain and it is advisable to sow seeds quite close, *c.* 5 cm. apart, and to thin out during the first rainy season. The more vigorous seedlings are ready for transplanting during the first year; smaller ones may be kept for another year in the nursery. Line sowing with field crops has proved successful. Regular weeding and loosening of soil should be carried out during the first two years and as often as may be necessary afterwards. The tree also reproduces from root suckers. The growth is comparatively slow, the mean annual girth increment being 0.65 cm.; reported mean girth of coppice at the end of 16 years, 14.25 cm. (Troup, III, 837–40; Cameron, 259).

The tree is subject to attack by several rot-causing fungi, *Fomes conchatus* (Pers.) Gillet, *F. rimosus* Berk., *F. caryophylli* (Rao) Bres., *Hexagonia discopoda* Pat. & Har., *Polyporus adustus* (Willd.) Fr., *Polystictus hirsutus* Fr., *P. steinheilianus* Berk., *Stereum hirsutum* (Willd.) Fr., *Ganoderma applanatum* (Pers.) Pat., *G. leucopheus* Mont. and *Trametes persoonii* Fr. The heartwood is damaged by the borer, *Aphrodisium cantori* Hope. Sapwood of felled and dead timber is liable to attack by *Monochamus bimaculatus* Gahan, *Xylotrechus smei* L. & G., *Agrilus malloti* Thery and *Sinoxylon* spp.; the attack is secondary. *Lyctus africanus* Les. and *Stromatium barbatum* F. attack dry wood (*Indian J. agric. Sci.*, 1950, **20,** 107; Khan, *Pakist. J. Sci.*, 1952, **4,** 65; Information from F.R.I., Dehra Dun).

Kamala tree has long been valued as the source of a dyeing material, known in the trade as Kamala, Kamala Powder or Kamala Dye, and used in the dye-

ing of silk and wool. The colouring matter is present in the red glandular pubescence covering the ripe capsules and is usually collected in February–March when the fruits ripen. The material collected from unripe fruits is greenish and of little or no commercial value. Kamala powder is used also as an anthelmintic. More recently, the oil extracted from the seeds has attracted considerable attention as a substitute for tung oil in the formulation of quick-drying paints and varnishes.

The tree is not cultivated on a plantation scale anywhere at present. It is widely distributed in forest lands throughout India and the collection of ripe fruits is not organized. No reliable data exist on the production of kamala dye in various parts of the country. Such information on the availability of seeds, as is available, is incomplete; according to the Indian Central Oilseeds Committee, the production of seeds in different States is as follows: Himachal Pradesh, 147; Uttar Pradesh, 2,865; Orissa, 1,396; West Bengal, 294; Jammu and Kashmir, 294; Assam, 184; Punjab, 20; Mysore, 20; and Bombay, 14 cwt. The cost of collection of seeds has been estimated at Rs. 20–54 per cwt. in various areas. Seeds (containing not more than 6% moisture) can be stored in gunny bags or tins in a dry place without appreciable deterioration for 6 months; after this period, seeds stored in gunny bags deteriorate rapidly.

Kamala dye—The red pubescence is separated from ripe fruit by beating and shaking; it may be obtained also by stirring the fruits vigorously in water, when the dye settles down as a sediment; the sediment is collected, dried and pieces of pericarp and other refuse separated by sifting. The yield of powder is 1.4–3.7% of the wt. of fresh fruits. Kamala dye is available as a granular, reddish brown resinous powder, almost without odour and taste. As met with in the trade, it is often impure due to careless collection, fraudulent admixture and contamination with sand and other inorganic impurities. Vegetable adulterants commonly used are powdered bark of *Casearia tomentosa*, powdered fruits of *Ficus bengalensis*, ground safflower (*Carthamus tinctorius*) and waras (*Flemingia macrophylla*). Kamala itself is often used as an adulterant of annato dye (*Bixa orellana*). Genuine samples of kamala powder contain 4–5% ash; but many commercial specimens contain 15–40% ash or even more. Sieving and elutriation reduce the ash content considerably (Trotter, 1940, 279; I.P.C., 132; U.S.D., 1955, 1729; Burkill, II, 1396; Rao & Seshadri, *Proc. Indian Acad. Sci.*, 1947, **26A**, 178; Lal & Mukerji, *Bull. Dep. Ind. Comm. Unit. Prov.*, *N.S.*, No. 12, 1940; B.V.C., 189; Wallis, 25).

Kamala dye is insoluble in cold water, slightly soluble in boiling water and freely soluble in alkalies, alcohol and ether, forming deep red solutions. The principal colouring principles are the salmon-coloured rottlerin ($C_{30}H_{28}O_8$, m.p. 212°) and its yellow isomer, *iso*rottlerin (m.p. 180–82°); together they constitute *c.* 11% of the wt. of the powder. Kamala contains, in addition, a small amount of *homo*-rottlerin (m.p. 192–93°), a low-melting (m.p. 60°) dark red resin (60%), a high-melting (m.p. 121–22°) yellow resin (5%) and a wax (m.p. 82°; *c.* 2%); traces of a volatile oil, tannins, gum and citric and oxalic acids are present. Rottlerin isomerises into *iso*rottlerin by treatment with aqueous alcoholic hydrochloric acid or boiling alcohol (Thorpe, VII, 91–92; Mayer & Cook, 204–08; Khorana & Motiwala, *Indian J. Pharm.*, 1949, **11**, 37).

Kamala was formerly employed extensively in the dyeing of silk and wool. It produces a bright orange or flame colour which is fairly fast to soap, alkalies and acids, but fades somewhat in sunlight. A boiling alkaline bath containing 4 parts of kamala, 1 part of alum and 2 parts of sodium bicarbonate is used for dyeing. The ingredients are previously mixed together in the powdered state with a small quantity of sesamum oil. The colour is heightened by the addition of turmeric. Kamala dye was at one time exported from India in fair quantities, but with the advent of synthetic dyestuffs, the use of this material has practically ceased (Thorpe, VII, 94; Burkill, II, 1396–97; Perkin & Everest, 398).

Kamala may be employed as an anti-oxidant for ghee, vegetable oils and shortenings. It prevents the development of rancidity and in the case of ghee, retards the loss of vitamin A. It is stable and harmless, without taste or odour and imparts a light yellow colour. It has been used for colouring foodstuffs and beverages. It is used also as a *sindhur* or *kumkum* by women in India (Govindarajan & Banerjee, *Curr. Sci.*, 1939, **8**, 559; Ramaswamy & Banerjee, *Ann. Biochem.*, 1948, **8**, 55, 115; Dhar & Aggarwal, *J. sci. industr. Res.*, 1949, **8B**, 1; Lal & Mukerji, loc. cit.).

The powder possesses purgative properties and in full doses occasionally causes nausea. It is, however, milder than Filix Mas and is usually administered in honey, milk or curds. The activity of the drug is

attributed to rottlerin and *iso*rottlerin, the latter being slightly more active; a 1 : 1 mixture of the two is more active than either of them alone. Kamala possesses pronounced inhibitory action on the succinic dehydrogenase of tapeworm and is considered effective as a taenifuge. For use as taenifuge, the drug should contain: total ash, $\ngtr$9%; acid-insoluble ash, $\ngtr$6%; and non-volatile ether soluble extractive, $\nless$66%. The drug is used also in veterinary practice.

Kamala is used in external applications for parasitic affections of the skin, such as scabies, ringworm and herpes, and is reported to possess lithontriptic and styptic properties. Oral administration in the form of emulsion reduces fertility in female rats and guinea pigs. The effect, however, is temporary; the animals return to normal after the drug is withdrawn. The antifertility factor is rottlerin; *iso*rottlerin is feebly active, if at all. Kamala is toxic to frogs, tadpoles and worms. A suggested method for assaying the drug in commercial samples is based on its toxicity to the fish *Haplochilus panchax*. Alcoholic extracts of the fruit show anti-bacterial activity against *Micrococcus pyogenes* var. *aureus* (I.P.C., 132; Chopra, 1958, 359; Khorana & Motiwala, loc. cit.; Singh & Chak, *Indian J. vet. Sci.*, 1956, **26**, 31; Nadkarni, I, 761; Gujral *et al.*, *Indian J. med. Res.*, 1960, **48**, 46, 52; Rao & Seshadri, *Proc. Indian Acad. Sci.*, 1947, **26A**, 178; George *et al.*, *J. sci. industr. Res.*, 1947, **6B**, 42).

Kamala Seed Oil—The pale white seed kernels (*c.* 60% of the wt. of seeds) yield on solvent extraction, 35–36% of a viscous, dark brown to pale yellow oil or semi-solid fat, depending upon the solvent used for extraction. Owing to the high viscosity of the oil and its tendency to polymerize, direct expression of seeds in a hydraulic press or in an expeller does not yield oil; only a small proportion of the oil present can be expelled in a hydraulic press at 70–80°. The oil can be extracted with light petroleum (b.p. 40–60°) which recovers *c.* 50% of the total oil in the seed; the residual oil can be extracted with benzene, ethyl ether or ethyl acetate. A high vacuum is used for stripping the solvent, as the oil polymerizes even at ordinary temperature (Aggarwal, *Kamala Seed And Its Oil*, Indian cent. Oilseeds Comm., 1958; Gupta & Aggarwal, *J. sci. industr. Res.*, 1953, **12B**, 545).

A process which uses linseed or other suitable vegetable oil for the extraction of kamala oil, has been patented. The seed kernels are ground with twice the amount of vegetable oil to form a thin uniform paste, heated for an hour and filtered hot; the residue is treated a second time in the same manner. The two extracts are combined and cooled when kamala oil separates out as a solid fat and is recovered by centrifuging. The solvent oil retained by the cake is pressed out in a hydraulic press or an expeller [Puntambekar, *Paintindia*, 1954, **4**(1), 85].

The characteristics of kamala oil are given in Table 1. The dark colour of the solvent extracted oil is attributed to the presence of kamala dye and of resinous impurities adhering to seeds. Washing seeds with 0.5% caustic soda prior to extraction, yields a pale coloured product. Kamala oil extracted with benzene or ether, polymerizes and gels rapidly, even more rapidly than tung oil. The fraction extracted with light petroleum ether is similar to tung oil in gelling characteristics. The Browne heat test values of oils extracted with light petroleum ether, commercial hexane and benzene are respectively, 9.5 min., 5.5 min. and 2.5 min. as compared to 11 min. for tung oil (Ojha *et al.*, *J. sci. industr. Res.*, 1956, **15B**, 551; Puntambekar, *Proc. Indian Acad. Sci.*, 1952, **35A**, 57; Ojha & Aggarwal, *J. sci. industr. Res.*, 1956, **15B**, 656).

The principal component acid of kamala oil is a solid hydroxy acid, kamlolenic acid (18-hydroxy-octa-deca-9, 11, 13-trienoic acid or 18-hydroxy

TABLE 1—CHARACTERISTICS OF KAMALA OIL

	Solvent			
	Light petroleum[1]	Petroleum ether[2]	Benzene[3]	Ethyl ether[4]
sp. gr.	0.9409 (at 40°)	0.9347 (at 30°)	0.9333 (33°/33°)	0.9444 (30°/30°)
	1.5052 (at 30°)	1.5105 (at 30°)	1.5156 (at 34°)	..
Acid val.	6.4	5.7	11.3	5.2
Sap. val.	195.0	178.3	207.6	190.7
Acet. val.	15.7–44	49.24	46.8	..
Hexabromide val.	0.3	..	..	..
Iod. val.	166.8 (Wij's)	183.2 (Hanus)	157.3	166.4 (Wij's)
Diene val. (Ellis & Jones)	40.4	42.9		48.5
Unsapon. matter, %	1.7	1.75	1.9	2.3

[1] Aggarwal *et al.*, *J. sci. industr. Res.*, 1948, **7B**, 136; [2] Puntambekar, *Proc. Indian Acad. Sci.*, 1952, **35A**, 57; [3] Singh & Saran, *Curr. Sci.*, 1942, **11**, 360; [4] Bhushan *et al.*, *Proc. Oil Technol. Ass. India*, 1949, 39.

α-elaeostearic acid). The fatty acid composition of the ether-extracted oil is as follows: kamlolenic, 58.5; conjugated dienoic, 4.5; linoleic, 11.7; oleic, 13.3; lauric, 0.1; myristic, 2.5; palmitic, 8.7; and stearic, 0.7%. Consecutive extractions of kamala seeds with petroleum ether and ether yields two fractions of the oil containing 37.4% and 81.8% of kamlolenic acid respectively. The unsaponifiable fraction of the oil consists mostly of sitosterol (Hilditch, 1956, 203; Gupta *et al.*, *J. Amer. Oil Chem. Soc.*, 1954, **31,** 287).

The major portion of kamala oil is composed of complex triglycerides formed by the condensation of carboxyl groups of various constituent fatty acids with the hydroxyl groups of both glycerol and kamlolenic acid; the rest of the oil (12%) consists of simple triglycerides of the component fatty acids (O'Neill *et al.*, *Chem. & Ind.*, 1954, 756; Kapadia & Aggarwal, *J. sci. industr. Res.*, 1958, **17B,** 117).

The oil can be stabilized against gelation at room temperature by the addition of 0.5–1% of hydroquinone or α-naphthylamine; the drying characteristics of the oil are not affected. The oil obtained by extraction with petroleum ether keeps better than that extracted with benzene (Kapadia & Aggarwal, *J. sci. industr. Res.*, 1955, **14B,** 186).

Kamala oil obtained by extraction with petroleum ether forms a good substitute for tung oil in the formulation of rapid-drying paints and varnishes. It can be employed in coating compositions giving either glossy or wrinkled finishes. The films are fairly resistant to heat, water, alkalies and organic solvents. Treatment of oil with monohydric alcohols, such as butyl or amyl alcohol, in the presence of hydrochloric acid modifies the gelation properties of the oil. Varnishes prepared from treated oil are comparable or only slightly inferior to tung oil varnishes [Aggarwal, *Oils & Oilseeds J.*, 1952–53, **5**(10–12), 19; Sharma & Aggarwal, *J. sci. industr. Res.*, 1952, **11A,** 308; Ojha *et al.*, ibid., 1957, **16A,** 213; Menon *et al.*, ibid., 1958, **17A,** 279).

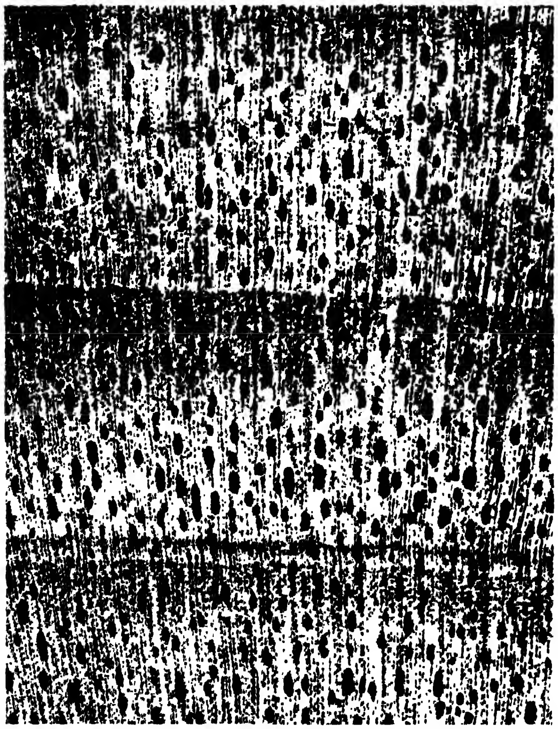
The oil may be employed in the formulation of hair fixers and ointments. Medium alkyd resins, superior to some of the commercial alkyd resins, have been obtained from kamala oil fatty acids. Kamlolenic acid and its hydrogenated derivatives have also been used in the preparation of macrocyclic compounds useful in perfumery, diaryl diketones useful as antioxidants or as high melting waxes [Puntambekar, *Paintindia*, 1954, **4** (1), 85; Sharma & Aggarwal, *J. sci. industr. Res.*, 1954, **13B,** 791; 1956, **15B,** 608; Gupta & Aggarwal, ibid., 1957, **16B,** 181; *J. Indian chem. Soc.*, 1956, **33,** 804].

A stand oil, named Friol, has been prepared from a 1:4 mixture of kamala oil (extracted with linseed oil) and linseed oil. Friol is more rapid drying than double-boiled linseed oil and forms films which have better gloss. It is an excellent vehicle for quick-drying paints, varnishes and wrinkle finishes (Puntambekar, loc. cit.).

Seed Cake—The seed cake left after the extraction of oil may be used as manure. It contains: moisture, 2.86; protein, 48.12; carbohydrates, 35.47; crude fibre, 6.57; and ash, 6.98%. The ash contains phosphate (0.7–0.8% P_2O_5) and potash. The cake can be used, in combination with saw dust, for making insulating boards and cork substitutes; the residual oil in the cake acts as a binder (Aggarwal *et al.*, *J. sci. industr. Res.*, 1948, **7B,** 136; Puntambekar, loc. cit.; Wehmer, II, 687).

Kamala Wood—The wood of kamala tree is whitish to light reddish grey, often with darker streaks, and somewhat lustrous; the heartwood is not distinct. It is fairly close- and straight-grained, medium fine- and even-textured, hard, moderately tough and heavy (av. wt., 48 lb./cu. ft.). It warps and shrinks badly and is liable to insect attack. It is somewhat difficult to saw, but can be worked to a smooth surface under tools. It is a relatively unimportant timber. Kamala wood is available in large supplies of small and irregular logs almost throughout India and used as fuelwood (calorific value: *sapwood* –4,835 cal., 8,704 B.t.u.). It is suitable for rafters, tool handles, match boxes and small turnery articles, like bobbins, cotton reels, penholders and rulers; it has been tried for paper pulp [Pearson & Brown, II, 889–91; Krishna & Ramaswami, *Indian For. Bull., N. S.*, No. 79, 1932, 19; Trotter, 1944, 198; Kapadia, *J. Gujarat Res. Soc.*, 1954, **16** (1), 18; Karamchandani, *Indian For.*, 1955, **81,** 424].

The leaves of kamala tree are used as fodder; mature leaves contain 3.29% nitrogen (dry basis) and 1.64% calcium; the ash (7.83%) is rich in potassium salts (K_2O, 6.25%). The leaves and bark contain tannin; the latter (tannin content, 6–10%) imparts a deep reddish colour to leather. The root is reported to yield a red dye (Laurie, *Indian For. Leafl.*, No. 82, 1945, 15; Puri, *Indian For.*, 1954, **80,** 700; Prasad & Dange, *Indian For. Leafl.*, No. 95, 1947, 10; Goswami & Kehar, *Proc. Indian Sci. Congr.*, 1956, pt III, 359; Burkill, II, 1397; Khan, *Pakist. J. For.*, 1956, **6,** 82; Rodger, 81).



F.R.I., Dehra Dun. Photo: S. S. Ghosh

FIG. 81. MALLOTUS PHILIPPENSIS—TRANSVERSE SECTION OF WOOD (×10)

All parts of the kamala tree are used in external applications for skin diseases. Roots, stems and leaves contain hydrocyanic acid; seeds contain a toxic glycoside (Kirt. & Basu, III, 2268; *Annu. Rev. biochem. Res. India*, 1957, **28**, 74; Burkill, II, 1397; Wehmer, II, 687).

M. barbatus Muell. Arg. is a low shrub found in parts of the western coast. The fatty oil extracted from the seeds is used for illumination and for making candles (Burkill, II, 1395).

M. nepalensis Muell. Arg. is a small tree found in central and eastern Himalayas and in Khasi hills up to an altitude of 2,400 m. The wood is used for huts, fencing and charcoal (Gamble, 619).

M. tetracoccus (Roxb.) Kurz syn. *M. albus* Muell. Arg. is a small evergreen tree found in eastern Himalayas, Assam and western ghats up to an altitude of 1,950 m. The tree is lopped for fodder. The wood (wt., 31 lb./cu.ft.) is suitable for match boxes and splints (Gamble, 619; Rama Rao, 370; Laurie, loc. cit.).

Mallow — *see* **Abutilon, Malva**

Mallow, Jew's—*see* **Corchorus**

Mallow, Marsh — *see* **Althaea**

Mallow, Musk — *see* **Hibiscus**

Mallow Tree, Yellow — *see* **Hibiscus**

MALPIGHIA Linn. (*Malpighiaceae*)

A small genus of evergreen trees or shrubs native of tropical America. About 4 species are grown in India, mainly as hedge plants.

M. glabra Linn. BARBADOS CHERRY

Bailey, 1947, II, 1973, Fig. 2308.

A slender, slow-growing, prickly shrub, 1–2 m. high, cultivated in gardens for its edible fruits and as a hedge plant. Leaves elliptic; flowers bright pink, *c.* 2.0 cm. in diam.; fruits scarlet red, about the size of a cherry, with thick skin; seeds large, four-angled.

The plant is propagated by seeds or by planting cuttings in October; it flowers in May and November. The fruits contain an orange-coloured, juicy pulp with fine flavour and are eaten raw or cooked. They are rich in ascorbic acid (1,000 to 4,000 mg./100 g. of edible pulp). The ascorbic acid content varies with clone, season, and ripeness of fruits: green fruits are richest while half ripe and fully ripe fruits contain much lower amounts. The fruits can be used in jams, preserves, sherbets, jellies, punch and beverages; the fruit beverage is reported to be good for sore throat. Canned juice of the fruits may be used to enrich the ascorbic acid content of other products such as pear and apricot nectar and grape juice. Frozen juice retains its bright red colour and practically all its ascorbic acid content. The fruits are considered useful in dysentery, diarrhoea and liver disorders (Williams & Williams, 214; *Chem. Abstr.*, 1947, **41**, 4247; Ledin, *Bull. Fla agric. Exp. Sta.*, No. 594, 1958; Hocking, 133).

The bark of *M. glabra*, called Nancebark, contains *c.* 26% tannin; it is used for tanning hides. It yields a dye which imparts a coffee-tint to silk and wool [Wehmer, II, 663; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6** (5), suppl., 69; *Chem. Abstr.*, 1931, **25**, 595].

M. punicifolia Linn. WEST INDIAN CHERRY

Chittenden, III, 1237.

TEL.—*Vallari*; KAN.—*Simeyaranelli*.

A shrub or a small-sized tree, up to 8.0 m. in height, cultivated in gardens in Madras and Mysore. Leaves variable in shape, obtuse, rounded or notched at base; flowers rose-coloured, in sessile clusters; drupes scarlet, ovoid or sub-globose, 1.0–1.5 cm. in diam., borne single or in clusters.

The plant is valued for its juicy, pleasantly acid fruits which resemble crab apple in flavour and used in jams, preserves and sauces. They contain ascorbic acid in high concentration, the green fruits being particularly rich. Analysis of the edible portion (83%) of the ripe fruit gave the following values: water, 83.9; protein, 1.6; fat, 0.1; total carbohydrates, 13.7; fibre, 1.0; and ash, 0.7%; calcium, 19 mg.; iron, 1.0 mg.; carotene (as vitamin A), 30 i.u.; thiamine, 0.02 mg.; riboflavin, 0.04 mg.; niacin, 0.5 mg.; and ascorbic acid, 1,000 mg./100 g.; green fruits contain up to 3,000 mg./100 g. of ascorbic acid (Information from Supdt., Lalbagh Botanical Gardens, Bangalore; Moscoso, *Econ. Bot.*, 1956, **10**, 280; Uphof, 227; Chatfield, *FAO nutr. Stud.*, No. 11, 1954, 38, 49).

M. coccigera Linn. and *M. urens* Linn. are two other species similar to *M. glabra* cultivated for their edible fruits and as ornamental hedge plants. They thrive in almost any soil and require occasional watering in summer; the growth is rather slow (Firminger, 242; Gopalaswamiengar, 279).

MALUS Mill. (*Rosaceae*)

A genus of small deciduous trees of the north temperate zone distributed in both hemispheres. Three or four species, including *M. pumila* (Cultivated Apple), have been recorded in India.

The apples have been frequently included along with pears under the genus *Pyrus*, but can be distinguished from pears, among other things, by the styles which are more or less connate at the base, the absence of stone or grit cells in the flesh and the presence of a distinct depression at either end of the fruits, which are mostly globular. The species of *Malus* hybridize with each other readily, but not with those of *Pyrus*.

M. baccata (Linn.) Borkh. syn. *Pyrus baccata* Linn.; *P. baccata* var. *siberica* Maxim. SIBERIAN CRAB APPLE

D.E.P., VI, 374; Fl. Br. Ind., II, 373; Rehder, 392.

HINDI—*Ban mehal, gwalam.*

PUNJAB *Baror, katsbal, liu, lhizo*; KHASI—*Soh-shur-um.*

A small round-headed tree with short trunk, up to 14 m. high, armed with simple or branched spines when old; leaves tomentose or glabrous, serrulate; flowers white; fruits sub-globose, 1–3 cm. in diam., red, scarlet or yellowish green with a few white spots, borne on long slender pedicels.

The Siberian crab apple is a native of the region extending from Siberia to Manchuria and Japan, and southwards to the Himalayas. Four or five varieties of this species have been recognized, including the Indian form *M. baccata* var. *himalaica* (Maxim.) Schneid. (Himalayan Crab Apple), which is found wild in the temperate Himalayas from Kashmir and Kumaon to Bhutan and Khasi and Jaintia hills in Assam, at altitudes of 1,800–3,000 m. This form flowers in April and fruits in October–November (Rehder, 393; Mansfeld, 134).

M. baccata is often prized as an ornamental: it has been used for the development of a number of types of crab apple and cultivated apple. The fruits of some crab apples are 2.5–3.8 cm. in diam. and are suitable for jellies and preserves. They have a tart flavour and an astringent taste before cooking. The fruits of var. *himalaica* are eaten in Lahoul and are said to have the true apple flavour. Crab apple is resistant to cold and some types withstand temperatures as low as −55°F. *M. baccata* growing round about Shillong and in Naga hills is compatible with apple and resistant to woolly aphis (Chandler, 1957, 276; Crane & Lawrence, 255; Gourley & Howlett, 508; Anthony, *Gdn J., N.Y.*, 1957, **7**, 187; Zielinski, 180; Henning, *Zuchter*, 1946–47, **17/18**, 289; Hayes, 380).

The wood of *M. baccata* (wt., 53 lb./cu.ft.) is similar to that of *Pyrus pashia* Buch.-Ham. It is hard and tough but is liable to warping.

M. sikkimensis (Hook. f.) Koehne is similar to *M. baccata*, but bears somewhat larger and moderately serrate leaves and speckled fruits. It is found in Sikkim Himalayas at 2,100–3,000 m. and in Bhutan. The fruit is said to be good when stewed. This species is apomictic; its seedlings are highly uniform and are suitable for use as rootstock. Promising results have been obtained by budding *McIntosh* apples on *M. sikkimensis* seedlings (Sax, *Proc. Amer. Soc. hort. Sci.*, 1949, **53**, 219).

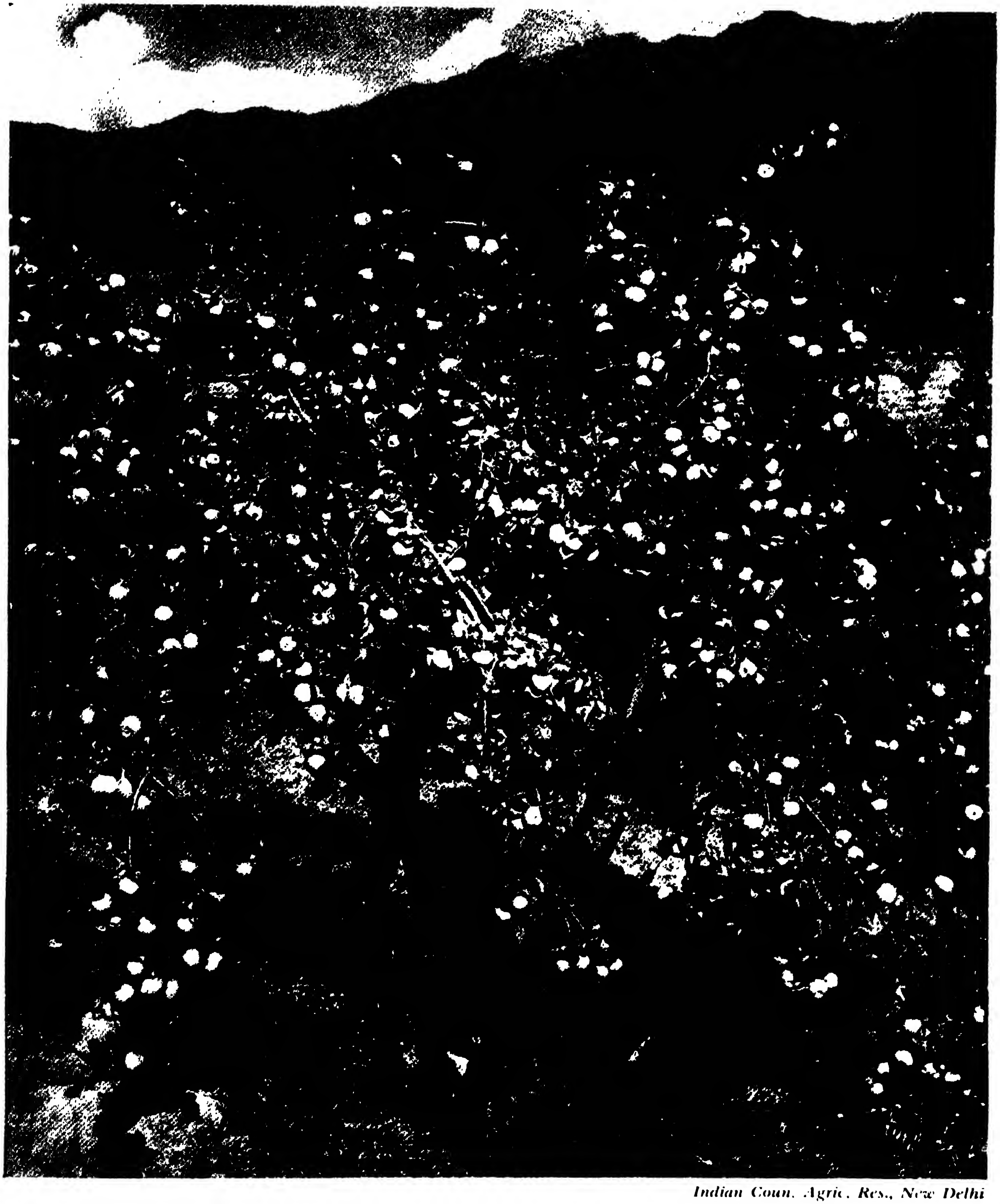
M. pumila Mill. syn. *M. communis* DC.; *M. sylvestris* Hort. non. Mill.; *M. domestica* Borkh.; *Pyrus malus* Linn. in part CULTIVATED APPLE

D.E.P., VI, 376; C.P., 910; Fl. Br. Ind., II, 373; Rehder, 391.

HINDI & BENG.—*Seb, sev*; KAN.—*Sebu, sevu.*

PUNJAB—*Seo*; LADAKH—*Kushu.*

A low round-crowned tree, usually up to 15 m. high, with tomentose or heavily pubescent young growth; leaves mostly clustered on short shoots or spurs, ovate



Indian Coun. Agric. Res., New Delhi

MALUS PUMILA — TREE IN FRUIT

or elliptic to broad elliptic, 4.5–10 cm. long, soft in texture with margins bluntly serrate; flowers white suffused with pink, borne in close clusters; fruit a fleshy pome, sub-globose, of varying size, shape and colour, with a depression at either end.

M. pumila is a variable species and its taxonomic position is much confused. Some consider it as the parent of most of the cultivated apples, although some of them may be offsprings of hybrids with *M. sylvestris* (Linn.) Mill., *M. prunifolia* (Willd.) Borkh. and *M. baccata*. Others include cultivated apples under the specific name *M. sylvestris* (Linn.) Mill. and consider them as varieties of the sub-species *mitis* (Wallroth) Mansfeld, while the wild apples of Europe or Acerb Apples are included under the sub-species *M. sylvestris* subsp.. *sylvestris* (Rehder, 391; Chittenden, I, 147; Bailey, 1949, 515; Mansfeld, 131; Clapham *et al.*, 558–59; Henning, *Zuchter*, 1946–47, **17/18**, 289).

The apple has been in cultivation from time immemorial, and remains of apple fruits and seeds have been found in the ruins of prehistoric lake dwellings in Switzerland. It is regarded as a native of the mountainous regions between western Himalayas on one side and Caucasus and Asia Minor on the other. In some areas of Caucasus and Turkestan, vast forests of wild apple trees are said to exist, and wild apples of Turkestan in particular, are said to be comparatively large and some of them are not inferior in quality to cultivated forms and a whole range of transition forms, from those bearing small sour fruits to those yielding large edible fruits are recognizable (Zielinski, 178–79; Chandler, 1957, 274; Gourley & Howlett, 504; Crane & Lawrence, 159).

Apple occupies the most important position among the fruits of temperate regions and is widely cultivated in many parts of the world. They are hardy and can be grown as far north as 65° latitude; they are not grown in the tropics, as they are cryophilous. The most important apple producing regions in the world are: United States of America, western and eastern Europe, Japan and Australia (Hill, 387–89; *Fruits*, Commonwealth Econ. Comm., 1960, 12–13, Tables 1 & 2; van Royen, I, 120).

Apple culture in India is said to have become established by about the middle of the eighteenth century both in the plains as well as in the hills of N. India; it is now a commercial crop in the hilly areas of Kashmir, Kulu and Kumaon. Cultivation has been tried also in parts of S. India, particularly in Bangalore and Nilgiris, but due to a severe attack of woolly aphis in 1897, the crops were destroyed. Cultivation has been recently revived by the introduction of new disease-resistant types [Hayes, 379; Thapar, *Indian Hort.*, 1956–57, **1**(2), 23; Javaraya, *Indian J. Hort.*, 1943, **1**, 31].

Of the estimated area of 40,000 acres under temperate fruits in India, the major part is under the apple. No reliable data are available regarding the acreage and production of apples in different States. The more important areas of cultivation are: Srinagar, Kulgam and Uttarmachipura tehsils in Kashmir and Udhampur and Kishtwar in Jammu; Almora, Naini Tal and Garhwal districts in Uttar Pradesh; Kulu valley in Punjab; Simla hills (Kotgarh) in Himachal Pradesh; and Bangalore and Nilgiri hills in S. India. Though temperate fruits form a minor part of the total area under fruits in India, there appears to be an almost unlimited scope for their cultivation especially in the Himalayan ranges, which can accommodate about four million acres of orchards. In these hilly areas, the yields from farm crops like wheat, barley and paddy, are generally lower than in the plains and apples can be more profitably grown. Further, there are millions of wild apple and pear trees and yields from them can be greatly increased by top working. The major obstacles for extending the cultivation of apples and other temperate fruits into these areas are the lack of communications in the interior parts and shortage of planting material of the right type [Sham Singh, *Farm Bull., Indian Coun. agric. Res.*, No. 19, 1957; *Agric. Marketing India, Bull. Marketing Some Important Stone, Pome and Small Fruits and Pine-Apples in India, Marketing Ser.*, No. 62, 1950, 4; Thapar, loc. cit.; Rao, *Indian J. Hort.*, 1947, **5**, 8].

About 6,500 horticultural forms of *M. pumila*, which can be distinguished on the basis of fruit and tree characters, are reported to be under cultivation in various parts of the world. Fruits vary in size, colour, flavour and quality; trees are adapted to different climatic and soil conditions and show differences in periods of maturity and seasons of bearing. The types commercially grown are mostly clones selected from seedling trees or bud mutations which are propagated vegetatively (Zielinski, 179; Hill, 388; Magness, *Yearb. Agric. U.S. Dep. Agric.* 1937, 575; Chandler, 1957, 274–76).

The types cultivated in India are mostly introductions from U.K. and other European countries and U.S.A.; a few have been introduced from Australia. They include both cooking and dessert types. Table 1

TABLE 1—CHARACTERISTICS OF SOME APPLE TYPES GROWN IN INDIA*

Type	Region in which grown	Fruit characteristics	Picking season	Remarks
Ambri Kashmiri	Kashmir	Medium to large size, oblong-elliptical, tapering; skin yellowish green, shining, three fourths striped with red; flesh white, crisp, juicy	End of September	Indigenous to Kashmir valley; good cropper with regular bearing; fruits available up to April
Baldwin	Kashmir & Kulu	Large, ovate-conical; skin deep bright red; flesh yellowish white, crisp, mildly sub-acid	October	Self-unfruitful; fruits keep till March
Red Delicious	Himachal Pradesh, Kashmir & Kulu	Medium to big with characteristic tapering shape and 5 prominent knob like protrusions; skin dull dark red; flesh white, tender, fine-grained, sweet, aromatic	September	Regular and self-fruitful; good cropper; fruits keep till October
Cox's Orange Pippin	Himachal Pradesh & Kulu	Medium size, roundish; skin orange red deepening to bright red; flesh yellow, firm, crisp, juicy, aromatic	Early August	Self-unfruitful; regular heavy bearer; fruit keeps till November; best dessert apple
King of Pippins	Kulu, Kumaon & Himachal Pradesh	Medium size, inclined to be oblong; skin smooth, orange yellow tinged with red; flesh yellowish white, crisp, juicy, sweet with rich flavour	July	Good dessert & cooking variety; fruit keeps till October
Golden Delicious	Himachal Pradesh & Kulu	Medium to large size, oblong with apex rounded and free from lobes; skin golden yellow; flesh of rich cream colour, very juicy, sweet & with a good blend of acidity	September	Fruits have a storage life of about three months
Royal (Starking) Delicious	Himachal Pradesh & Kulu	Bud sport of Red Delicious; medium size; skin waxy, shining with white bloom; flesh yellow, sweet, juicy with excellent flavour	August September	Keeps well
Jonathan	Kumaon & Punjab	Medium size, oblong to conical; skin smooth, rich red with yellowish dots; flesh light yellow, tender, sub-acid.	September	Self-fruitful; a good storage variety; fruits keep till March
Yellow Newton	Kulu	Large, roundish to slightly flat; skin greenish yellow with brownish red cheek; flesh cream-coloured, crisp, juicy	September	Fruits keep till March
Red Astrachan	Kulu & Punjab	Medium to large, roundish; skin thin with deep red cheek; flesh white, crisp, juicy, aromatic	End of June	A good early variety; prolific; keeping quality poor
Blenheim Orange	Kumaon & Kulu	Large, roundish, slightly flattened; skin greenish yellow with brownish red cheek; flesh firm, juicy, aromatic	September	Good cropper; self-unfruitful; fruits keep till February
Newton Wonder	Himachal Pradesh	Large, roundish, slightly flattened; skin greenish yellow with brownish red cheek; flesh firm, juicy, aromatic		A good cooking apple; self-fruitful; good cropper; fruits keep till May
Rome Beauty	Bangalore, Nilgiris, Kumaon & Punjab	Medium to small, round; skin thick, yellow, striped with bright red; flesh yellow, crisp; mild sub-acid flavour	September	A dwarf type susceptible to woolly aphis; self-fruitful; fruit keeps till February
Irish Peach	Nilgiris	Small, flat, slightly ridged; skin brilliant scarlet with yellow patches; flesh soft, mealy when ripe, sweet, aromatic		Immune to woolly aphis

* Sham Singh, *Farm Bull., Indian Coun. agric. Res.*, No. 19, 1957; *Agric. Marketing India, Bull. Marketing Some Important Stone, Pome and Small Fruits and Pine-apples in India, Marketing Ser.*, No. 62, 1950, 56; Naik, 319 21; Thapar, 85 88.

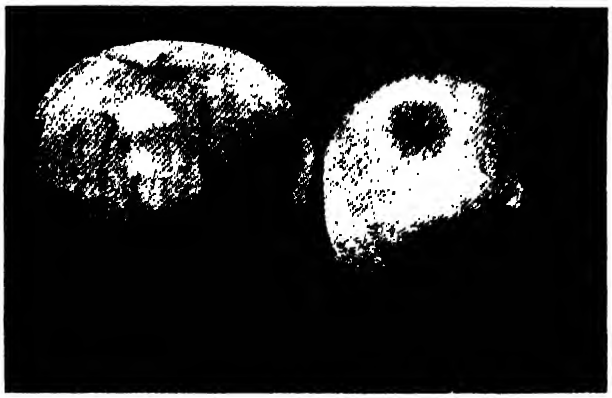
summarizes the characteristics of some important types grown in India.

Cultivated types are generally diploids with 34 chromosomes, but there are quite a number which are also triploids with 51 chromosomes; only a few are tetraploids with 68 chromosomes. Some characteristics of triploids are of value from a commercial standpoint; the trees grow vigorously and yield large fruits, which in many cases, have good storage quality (Crane & Lawrence, 207, 214; Chandler, 1957, 278, 285; Sham Singh, loc. cit.).

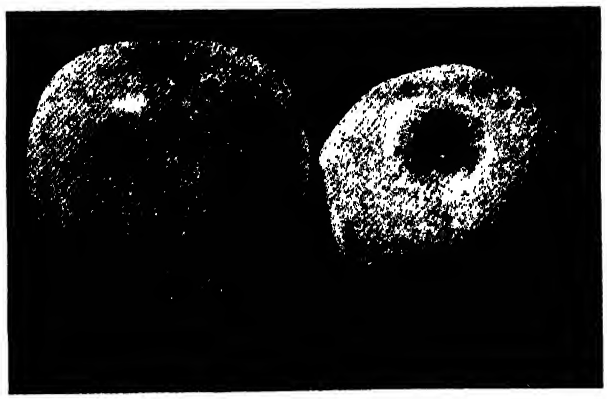
Cultivation

The apple plant is essentially suited to regions which have a low winter temperature, attended by snowfall. It requires considerable chilling to check the rest period and induce the opening of buds in spring. If the winters are not sufficiently cold, blossoming as well as fruiting are insufficient and uneven. There are, however, considerable variations among cultivated types in the degree of chilling required to induce bud opening; some need chilling for a short duration, while others require long and cold winters. An annual rainfall of 60–75 cm. is considered necessary, though trees can flourish with much less or tolerate far more rain; the distribution of rainfall during the year is more important. Heavy summer showers or hail storms cause damage to growing fruits, while late autumn rains delay the movement of trees into dormancy, thereby leading to insufficient winter rest. Heavy snowfall is physically injurious, unless the trees are pruned to provide a strong framework. Late spring frosts are particularly detrimental to early flowering varieties owing to their scorching effect on leaf and blossom (Rao, *Indian J. Hort.*, 1947, **5**, 8; Sham Singh, loc. cit.; Thapar, 83).

Soil —Apple thrives best in well-drained medium loam, but it has been successfully grown on a variety of soils ranging from the deep fertile loams of Kashmir to the light loams of Kulu valley and the brown or reddish brown sandy loams of Kumaon. In Bangalore, it is grown in areas where the soil layer is just two feet thick above an impervious rocky



Ambri Kashmiri



Golden Delicious

Red Delicious

Baldwin

I.C.A.R., New Delhi

FIG. 85. MALUS PUMILA—SOME CULTIVATED TYPES OF APPLE IN INDIA

substratum ; the trees, however, neither live long nor attain the luxuriant growth seen in N. India ; they give only moderate yields. The roots of the tree are more resistant to wet and poorly aerated soils than roots of many other deciduous orchard plants. Where apples are planted on level ground, as is done at Bangalore, they are cultivated in the same way as other trees ; in N. India, they are grown on slopes and hillsides, and suitable measures for conserving moisture and for preventing erosion are necessary. The northern aspect of slopes are chosen and terraces are made to slope inwards towards the hillside ; besides attending to proper drainage, lime is applied to check soil erosion (Hayes, 380–82 ; Das, *Indian Fmg*, 1947, **8,** 344 ; Chandler, 1957, 307).

Propagation– The apple is usually propagated by budding or grafting suitable types on selected rootstocks ; plants raised from seeds do not grow true to type. The rootstock used varies in different areas. In Kashmir and Kulu, seedlings of crab apple (*M. baccata*) are commonly used. In Kumaon, the practice is to collect seeds of wild crab apple or of any available apple types for raising seedling stock. *Northern Spy*, a type resistant to woolly aphis, is the most popular rootstock in Bangalore. In England and the Continent, the practice of using seedling rootstocks has been given up and clonal or vegetatively propagated rootstocks of known performance are employed ; the patchy appearance resulting from the use of seedling stocks is thereby avoided.

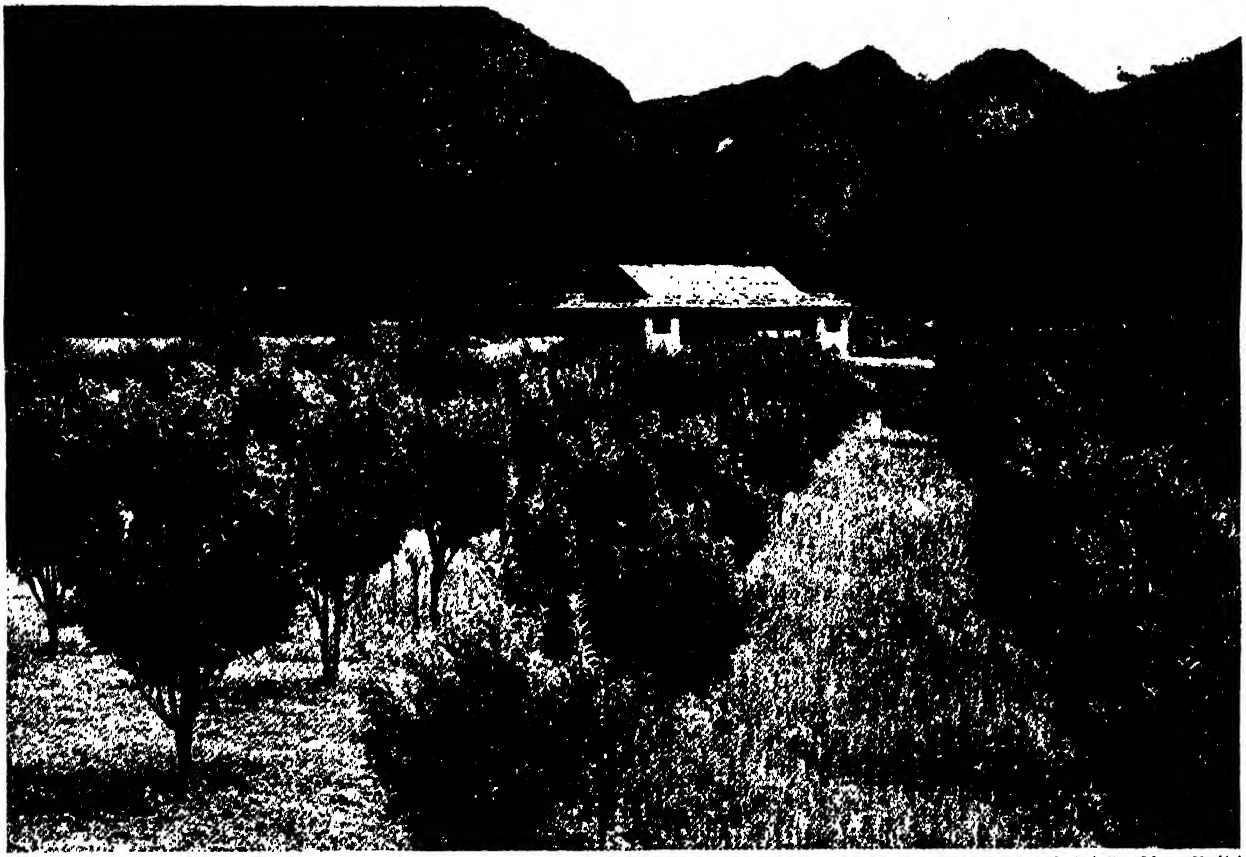
The rootstock influences the size of the tree, its vigour, cropping capacity and speed of maturation ; certain scions exert a noticeable influence on rooting behaviour. Because of this inter-relationship between stock and scion, the use of the right type of rootstock is as important as the selection of the scion. A tree that grows on a rootstock to the same size as it grows on a crab apple seedling is known as a 'standard tree' ; the rootstock is known as a 'standard or free stock'. One on a rootstock that reduces its rate of growth is known as a 'dwarf tree' : and the rootstock itself is called the 'dwarfing stock'. In recent years, a large number of rootstocks of known performance have been distributed by the East Malling Research Station and John Innes Horticultural Station, Merton, England. Of these, *Malling I IX* are dwarfing stocks, with *Malling I* dwarfing the least and *Malling IX* dwarfing the most. *Malling X–XVI* are vigorous and are considered suitable for raising standard or half-standard trees. Dwarfing types are useful where space is the main consideration ; they come into bearing earlier than standard types. In Kashmir, Kulu and Simla hills standard trees are popular, while bush and dwarf trees are popular elsewhere (Sham Singh, loc. cit. ; Chandler, 1957, 311 ; Rao, *Indian J. Hort.*, 1947, **5,** 8 ; Gourley & Howlett, 481 ; Singh, *Indian Fmg*, 1941, **2,** 242 ; Chittenden, I, 148).

Rootstocks can be raised from seeds or they can be vegetatively propagated by stooling or layering. Vegetative propagation is preferred, since the known qualities of the stock are retained. If the stock is vigorous, layering is considered better, while stooling is preferred if the stock is weak. The scion is worked on the stock by budding or grafting. For budding, T- or shield-budding is the usual method adopted ; for grafting, a modified bench or tongue grafting is employed. A modified root grafting method is sometimes used in Kumaon which though easy is not recommended, as it induces the scion to root, thus nullifying the effect of rootstock on scion. Whip grafting has proved more successful than shield budding in Nilgiris (Singh, *Indian Fmg*, 1941, **2,** 242 ; Sham Singh, loc. cit. ; Bajwa *et al.*, *Punjab Fmr*, 1952, **4,** 266 ; Chandler, 1957, 291, 309 ; Naik, 322–23).

Budding is done between April and September when the flow of sap is active both in the scion and in the stock. For early budding, scion wood is taken from the pruning of the preceding season, which is preserved for the purpose ; for late budding, fresh mature shoots are used (Singh, *Indian Fmg*, 1941, **2,** 242).

Planting—Types grown on free and seedling stocks are planted 25 30 ft. apart, while bush-trained plants on semi-dwarfing stocks are set 15 18 ft. apart ; the planting distance in the case of plants on dwarfing stocks is 12 15 ft. One year old plants are preferred for planting in the orchard, as they take root readily and can be trained to any shape. Planting can be done at any time during the dormant period ; in the colder regions, early spring is considered to be the best time (Sham Singh, loc. cit.).

Manuring—The application of about five baskets of farmyard manure in each hole at the time of planting and ten cartloads per acre yearly thereafter has been recommended. In Kashmir, where the soil is naturally fertile, manuring is done, if at all, once in three or four years. Farmyard manure is supplemented by bone-meal and superphosphate when applied to micaceous soil. Nitrogenous manures, like ammonium sulphate, may also be used in place of



I.C.A.R., New Delhi

FIG. 86. MALUS PUMILA—AN ORCHARD IN KULU (PUNJAB)

farmyard manure, in a dosage of 1–16 lb. of nitrogen for each year of tree age. In the case of acid soils, an application of 1–3 tons of limestone per acre once in five years is recommended (Hayes, 380–81 ; Das, *Indian Fmg*, 1947, **8**, 344 ; Sham Singh, loc. cit.).

In Kashmir, Kumaon hills and Himachal Pradesh, the orchards are mostly rainfed, but in Kulu valley they are generally irrigated. Even under rainfed conditions, irrigation is beneficial for the first year or two. Mulching with leaves or grass has been recommended both for preserving soil moisture and for producing organic matter (Thapar, 88 ; Hayes, 380).

Pruning—Pruning is necessary to improve the shape of the tree and to stimulate growth, flowering and fruiting. In Kashmir, a tree with an open centre with the lowest branch 4–5 ft. from the ground, is preferred. The modified leader or delayed open centre form of framework is considered better as trees trained in this form develop strong crutches. Branches of mature trees should be lightly pruned every year to keep the centre open ; congested parts should be thinned and long growths cut back to encourage spur growth. Old trees bearing heavy crops of small sized fruits need severe pruning. In regions subject to hail, late pruning is reduced to a minimum as crowding of branches serves as protection to fruit. Pruning wounds are coated with an antiseptic (Hayes, 381 ; Sham Singh, loc. cit. ; Naik, 325 ; Thapar, 89–90).

Flowering & Fruit-setting—Apple trees begin to bear enough flower buds to give a worthwhile crop only 5–6 years after planting ; they rarely reach full bearing before they are 12–18 years old. Dwarf trees come into bearing sooner than standard trees. The bulk of the crop is borne either on short modified shoots (spurs) or on one year old wood or on both. Fruit buds are borne terminally on long lived spurs or laterally on one year old branches ; they occur mixed with leaf buds (Chandler, 1957, 278–79, 281, 311 ; Naik, 325 ; Hayes, 381).

A large proportion of fruit buds fail to open, if the winter is not sufficiently cold or long. Varieties which require a minimum of chilling are selected for orchards. Opening of buds may be favoured by proper orchard management and spraying with certain chemicals. In Bangalore where the climate is not cold enough dormancy is induced by controlled irrigation and root pruning. Dusting with calcium cyanamide or spraying with copper salts causes defoliation and induces dormancy; other suggested measures are: shading of apple trees and white washing of trunks and branches to reduce the potency of winter sunshine, spraying with mineral oil or 3–5 dinitro-*o*-cresol mineral oil emulsion [Hill & Campbell, *Emp. J. exp. Agric.*, 1949, **17,** 259; Rao *et al.*, *Indian J. Hort.*, 1952, **9**(4), 59].

Nitrogen and water deficiencies may cause abscission and fall of flowers and young fruits. Insufficiency of pollination may lead to mis-shapen fruits; apple pollen is carried by insects and too little of it may be transported if the weather at blossoming time is unfavourable. A number of apple varieties, particularly triploid types, bear pollen of rather low viability and tend towards sterility. Several types are self-incompatible to varying degrees. A moderate degree of self-incompatibility is desirable as otherwise the tree may bear an excess of small fruits or it may cause biennial or alternate bearing; when self-incompatibility is pronounced, the yield of fruit will be poor. In such cases, cross-pollination results in better crops than self-pollination and this emphasises the necessity for planting together in orchards different interfertile types with overlapping blossoming periods. Branches of pollinating types may also be grafted on self-sterile trees (Chandler, 1957, 282–86; Sham Singh, loc. cit.; Naik, 323).

Apple culture in S. India differs in certain respects from that in north Himalayan areas. Both Bangalore (altitude, 900 m.) and Nilgiris (altitudes, 1,500–1,800 m.) are climatically unsuitable for the optimum growth of apples, as they have a mild winter with temperatures much above 30°F. The trees do not attain the size of those growing in Himalayan regions; nor do they live so long or yield so plentifully. The types grown in these areas are mostly subtropical. In Bangalore, the plants are raised on *Northern Spy* rootstock; in Nilgiris, *Merton Stocks 778* and *779* which, like *Northern Spy*, are resistant to woolly aphis are considered useful. In Bangalore the rest period is artificially induced twice a year, once in January or February when the plants are not very active and again in August or September when there is a break in the monsoon, by withholding water for some time, digging the soil around the plant and exposing and pruning the small fibrous roots; when the leaves wilt and fall off, exposed roots are covered with a thin layer of sand and the pit filled up with compost or a suitable fertilizer mixture. Treated plants begin to blossom in about a fortnight (Naik, 318, 324–25; Hayes, 382; Javaraya, *Indian J. Hort.*, 1943, **1,** 31; Aiyangar & Aiyangar, *Poona agric. Coll. Mag.*, 1930–31, **22,** 160; Rao, *Indian J. Hort.*, 1947, **5,** 8; Krishnamurthi, 121–22; Kuppuswami, *S. Indian Hort.*, 1958, **6,** 59).

The economic life of the apple tree differs from area to area and seems to depend on climatic as well as cultural conditions. The life is reported to exceed sixty years in Kulu and Kashmir; it is forty in Kumaon and twenty-five in the Nilgiris; in Bangalore the economic life does not exceed 6–10 years (Rao, *Indian J. Hort.*, 1947, **5,** 8).

Diseases—The apple is subject to a large number of diseases. Stem black (*Coniothecium chomatosporum* Corda) and stem brown (*Botryosphaeria ribis* Grossenb. & Duggar) cause serious damage to apple crop, particularly in Kumaon. The infecting organisms enter the plants through pruning wounds. Stem black manifests itself in July and is very virulent by mid-August; jet black streaks appear on affected stems, followed by cankers and eventual death; some strains of the fungus cause also apple cracking and branch blisters. Stem brown disease makes its appearance usually towards the end of April and is virulent by the middle of May; it causes die back and loosening of bark which becomes papery and rolls outwards. Both diseases are controlled by painting pruning wounds with a paste containing red lead (2 oz.), copper carbonate (2 oz.) and raw linseed oil (100 c.c.); lanolin may be employed in place of linseed oil. Spraying of plants with lime-sulphur twice during the spring affords protection against stem black (Hayes, 386; Dey & Singh, *Indian J. agric. Sci.*, 1939, **9,** 703; Singh, ibid., 1942, **12,** 368).

Pink disease (*Corticium salmonicolor* Berk. & Br.) causes considerable damage to apples in Kumaon and Coonoor. The infection is at its peak from August to the middle of September. Small pustules, white in colour, appear all over the affected portion and they ultimately break through the bark throwing out pink coloured masses of the size of pin heads: leaves turn brown and wilt. As control measures, forks of branches and pruning wounds

should be painted with red lead-copper carbonate paste. Affected branches should be removed and burnt and all alternative hosts in the neighbourhood destroyed (Singh, *Indian J. agric. Sci.*, 1943, **13,** 528).

Brown rot, caused by *Sclerotinia fructigena* Aderh. & Ruhl., causes heavy damage to apples in Punjab. The pathogen overwinters on mummied (shrivelled) apples, hibernating on the fruit spur and producing canker round the base. All affected parts including fruits, should be removed and destroyed. Spraying the trees with 2:4:50 Bordeaux mixture at pink bud and calyx stages and again two weeks later is said to be useful (Sham Singh, loc. cit.; Hayes, 386).

Collar or root rot, caused by an unidentified fungus, originally believed to be *Corticium rolfsii* (Sacc.) Curzi, is a serious disease in Bangalore. It is checked to some extent by fixing burnt clay rings (c. 18 in. diam.) around the stem collar and exposed root, and washing with Bordeaux mixture (Aiyangar & Aiyangar, *Poona agric. Coll. Mag.*, 1930–31, **22,** 160; Naik, 329).

Another collar rot caused by *Rosellinia* sp. is a serious disease in localized patches in orchards in Kumaon. It may be controlled in the early stages by scraping off or excising diseased portions and painting with red lead-copper carbonate paste; treated trees are subsequently manured to stimulate new root formation (*Annu. Rep. Hill Fr. Res. Scheme, U.P.*, 1946 47, 20).

Apple scab (*Venturia inaequalis* Wint.) occurs commonly on leaves, young wood, fruits and flowers. Affected fruits do not keep well, while leaves and young twigs dry up or fall off prematurely. The fungus overwinters on fallen dead leaves, fruits and young wood. Control measures include collecting and burning diseased material, spraying the trees with Bordeaux mixture and lime-sulphur wash from the time of the opening of flowers to the maturity of fruits [Keitt, *Yearb. Agric. U.S. Dep. Agric.*, 1952, 646; Sham Singh, loc. cit.; Bracer, *Punjab Fmr*, 1950, **2**(1), 36].

Mildew (*Oidium* sp.) causes some damage in the Nilgiris. Removal of diseased leaves and spraying with Bordeaux mixture afford control. Powdery mildew [*Podosphaera leucotricha* (Ell. & Everh.) Salm.] affects leaves, stems, flowers and young fruits causing in certain years serious damage in Kulu and Kangra valleys, especially to nursery stock. Pruning of affected twigs in winter and spraying with lime-sulphur, iron sulphite, sodium polysulphide or Bordeaux mixture are recommended [Sham Singh, loc. cit.; Bedi, *Indian Hort.*, 1956–57, **1**(3), 11; Sprague, *Yearb. Agric. U.S. Dep. Agric.*, 1953, 667].

Leaf spot (*Phyllosticta pirina* Sacc.) is common in Kumaon. It appears by the end of June and is most virulent by mid August. Spraying of trees with 2:10:40 Bordeaux mixture at the dormant, open cluster or petal fall stage and collecting and burning all dead leaves during winter afford effective control (Singh, *Indian Fmg*, 1944, **5,** 566).

Two other leaf spot diseases have been recorded; they are caused by *Myxosporium microsporum* Cooke & Harker and *Cercospora mali* Ell. & Everh. A stem canker caused by *Sphaeropsis malorum* Berk. =*Physalospora obtusa* (Schw.) Cooke has also been reported (Mundkur & Kheswalla, *Indian J. agric. Sci.*, 1943, **13,** 397; *Annu. Rep. Fr. Res. Sta., Hessarghatta, Mysore*, 1942–43, 4–5; *Indian J. agric. Sci.*, 1950, **20,** 107).

Pests Among the pests affecting apple trees in India, the San Jose scale, *Quadraspidiotus* (*Aspidiotus, Aonidiella, Forbesaspis*) *perniciosus* Comstock, is the most serious. It has a wide range of host plants, including fruit plants belonging to *Rosaceae*. The pest is usually dispersed through nursery stock, scion or graft; many kinds of insects and common birds, like crow, mynah and bulbul, also act as dispersing agents; the pest may be carried from plant to plant at the time of fruit picking and nymphs may crawl along the ground and infest new plants. The insect is attacked by a number of natural enemies and predators. Spraying of trees in the dormant season (November–February) with an emulsion of potash-fish oil soap and diesel oil in water, followed by further spraying in summer provides control. Fumigation of nursery stock before planting and elimination of infested wild plants round about the orchard are recommended (Hayes, 384; Fotidar, *Indian Fmg*, 1941, **2,** 234; Rahman, ibid., 1944, **5,** 463; Kalra, *Punjab Fr. J.*, 1946, **10,** 75; Rao, *Indian J. Ent.*, 1948, **10,** 41; *Indian For.*, 1957, **83,** 351).

The scale insects recorded on apple from various regions of India include: *Hemiberlesia rapax* Comstock, *H. lataniae* Signoret, *Chrysomphalus dictyospermi* Morgan, *Duplaspidiotus tesseratus* de Charmoy, *Howardia biclavis* Comstock and *Pseudaulacapsis pentagona* Targioni (Rao & Chatterjee, *Indian J. Ent.*, 1948, **10,** 5).

Woolly aphis, *Eriosoma lanigerum* Hausmann, is a severe pest in many orchards. The insect is reported to reproduce sexually in Kashmir, while in Kumaon

and Punjab, its development is parthenogenetic and viviparous and several broods are produced especially in summer. In some localities, the pest migrates in winter from the aerial parts to the roots and in the reverse direction in summer. Winged forms appear during July–October. Nymphs may be blown from tree to tree in loose masses of wool or they may crawl over to neighbouring trees. Aerial parts as well as roots are attacked and get covered with galls; the vitality of trees is lowered and young plants succumb to the attack. In extreme cases, the roots disintegrate to such an extent that trees are blown away by high winds. Fruits from infected plants are small, malformed and of poor quality.

Budding of apple types on woolly aphis-resistant stocks, like *Northern Spy* and *Merton Stocks 778* and *779*, has been effective in controlling the pest in Bangalore and Nilgiris; in Kumaon, local *Malus baccata* stock, said to be aphis-resistant has been employed. Spraying in summer with soft soap-nicotine and in winter with tobacco resin soap affords control. The root-infesting forms can be controlled by *p*-dichlorobenzene applied in a 4 in. deep circular trench, 5–10 ft. away from the trees. The aphis is kept in check in Kumaon, from early spring to mid-summer, by a predator beetle, *Coccinella septempunctata* Linn. This beetle occurs in Punjab also, but it does not prey upon the aphis; three other insect predators, *Chilomenes bijugans infernalis* Muls., *Syrphus confrater* Weid. and *Ancylopteryx punctata* Hag. exercise a definite check on the aphis in Punjab. The parasite, *Aphelinus mali* Hald. introduced into Punjab hills from America in 1936, is now well established and the pest has been kept under check. Its introduction in Kumaon and Coonoor has, however, not met with much success (Rahman & Khan, *Indian J. agric. Sci.*, 1941, **11**, 265; Singh, ibid., 1942, **12**, 588; Rao, *Indian J. Hort.*, 1945, **3**, 44; Sham Singh, loc. cit.; Isaac & Renjhen, *Indian Fmg*, 1946, **7**, 346; Lal & Singh, ibid., 1945, **6**, 24; *Indian J. agric. Sci.*, 1947, **17**, 211).

The root borer, *Lophosternus* (*Dorysthenes*) *hugelii* Redtembach, is a serious pest of the apple in Almora and Naini Tal districts of Kumaon; it has also been recorded from the hills in N. India up to a height of 2,100 m. The application of *p*-dichlorobenzene, 3 in. below the surface of the ground at 1 oz. per linear foot is reported to kill the grubs within a distance of 6 in. (Sharma & Singh, *Bull. Dep. Agric. U.P.*, No. 21, 1940; Singh, *Indian J. agric. Sci.*, 1941, **11**, 925).

A hairy caterpillar, *Lymantria obfuscata* Wlk., is a pest on the apple in Simla hills, Kulu and Kashmir; it defoliates the trees. *Euproctis signata* Blanchard, another caterpillar reported from Kashmir and N.W. Himalayas, causes injury to buds, flowers, foliage and fruit. A yellowish red caterpillar, *Zeuzera* sp., is a stem borer occurring in Kumaon; it remains in the stem for 12–24 months throwing out yellow bead-like excreta. Control measures include picking out caterpillars and destroying them and their egg clusters. Spraying the plants with lead arsenate-lime mixture or dusting with sodium fluosilicate and ash affords control. Other pests recorded on apple are: tent caterpillar (*Clisiocampa indica* Wlk.), a fruit borer (*Cacoecia epicyrta* Meyr.), May beetle or June bug (*Mimastra* sp.) and a weevil (*Myllocerus* sp.) (Rahman & Kalra, *Indian Fmg*, 1944, **5**, 312; Janjua, *Indian J. Ent.*, 1947, **9**, 159; Sharma & Singh, *Bull. Dep. Agric. U.P.*, No. 21, 1940; Hayes, 385; Sham Singh, loc. cit.; *Annu. Rep. Fr. Res. Sta., Hessarghatta, Mysore*, 1942–43, 5; Krishnamurti & Appanna, *Mysore agric. J.*, 1951, **27**, 1).

The codling moth, *Laspereysia* (*Carpocapsa*, *Cydia*) *pomonella* Linn., causes damage to apples in Baluchistan. Except for a doubtful record of its occurrence from Ladakh, this pest has not been reported elsewhere in India, but the possibility of its introduction through imported consignments of fruits cannot be discounted. The larvae of *Euzophera punicella* Moore and *Cacoecia sarcostega* Meyr. attack fruits infested with codling moth larvae, entering through holes made by the latter and causing serious damage to crops. Control measures include spraying with lead arsenate at the calyx stage and again spraying four times with a cover spraying of lead arsenate and fish oil. Fumigation of harvested fruits with methyl bromide is recommended (Pruthi, *Indian J. agric. Sci.*, 1938, **8**, 499; Janjua *et al.*, ibid., 1943, **13**, 113; Sen Gupta, ibid., 1951, **21**, 67).

Harvest & Yield—Where the fruit set is heavy, thinning is necessary to maintain a balance between vegetative growth and fruit production and to improve the size, colour and quality of fruit. This is done as early as possible after fruit set, so that the retained fruits may be 4 6 in. apart from each other and only one fruit is left in each cluster (Sham Singh, loc. cit.; Rao, *Indian J. Hort.*, 1947, **5**, 8).

The mature fruit can be separated from the branch by a slight turning pull. Considerable care is needed in gathering and handling fruits. Any injury to the

skin renders the fruit liable to attack by rot organisms. The correct stage of ripening is judged more by the disappearance of green colour and brightening of yellow or whitish areas (i.e. under colour or ground colour) rather than the ease of picking or the amount of red colour. If picked too soon, the fruits are subject to bitter pit and scald during storage: they are also likely to be of poor dessert quality. If picked too late, they are likely to have a short storage life (Chandler, 1957, 296: Sham Singh, loc. cit.).

Early varieties like *Red Astrachan* and *King of Pippins* are harvested in June and July while late varieties like *Ambri, Yellow Newton, Rome Beauty* and *Blenheim* are harvested in September: a few like *Baldwin* are harvested in October. In Mysore, where the predominant type is *Rome Beauty*, the early crop is harvested between July and September and the late crop between December and February. In Nilgiris and Bangalore, the summer crop comes to the market at a time when supplies from the north are scarce (Sham Singh, loc. cit.; Javaraya, *Indian J. Hort.*, 1943, **1,** 31; Naik, 327).

The yield of fruits varies greatly in the different apple-growing areas. In Kulu, yields up to 1,250 lb. per acre have been recorded, while in Kashmir, the average yield per tree is estimated at 150 lb. A yield of 100 lb. per tree is reported in Kumaon, while in Bangalore and Nilgiris, the yield does not exceed 25 lb. per tree (Rao, *Indian J. Hort.*, 1947, **5,** 8).

Apples after harvesting should be cleaned by wiping or washing to remove dirt and spray residues. A dilute solution (1%) of hydrochloric acid is employed to remove lead carbonate residues; fish or mineral oil is removed first by washing with warm water containing sodium silicate (0.4–0.8 lb./gal.) and then with dilute acid (Smock & Neubert, 177, 179).

Grading—Based on size and shape, colour and permissible skin blemishes, apples are graded as: super, fancy, selected and commercial. The grades recognized in Simla hills are: extra large, large, medium, small and extra small; fruits which are unsuitable for marketing are peeled, cut into rings and dried. In Bangalore, apples are sorted on the basis of colour and size into three grades: broken, diseased or otherwise damaged fruits are rejected (*Bull. Marketing Some Important Stone, Pome and Small Fruits and Pine-apples*, 1950, 28–29, 78; Aiyangar & Aiyangar, *Poona agric. Coll. Mag.*, 1930–31, **22,** 160).

Storage—Among the temperate fruits in India, apple is the only one which is stored to meet the demands of consuming markets throughout the season. In Kulu valley and Simla hills, apples are stored on racks or in wooden boxes. In Kumaon, they are stored on the floor or in wooden trays or racks; sometimes they are stored in heaps and covered with moss to prevent shrivelling. This practice is deprecated as it retards the storage life and imparts a musty smell to fruits. Storage of crates on racks in ventilated masonry godowns at 90% humidity is recommended to increase storage life. Delay between picking and storage should be avoided as it reduces the storage life. Fruits gathered at different stages of maturity are stored separately. Refrigerated storage permits a longer life. *Delicious* apples may be stored for 3–4 months at 35–38°F. and 85–90% R.H., while *Rome Beauty* and *Baldwin* have a life of 5–7 months at 31–32°F. and 85–88% R.H. In the case of certain types, storing in a modified atmosphere in which the concentrations of oxygen and carbon dioxide are controlled is recommended (*Bull. Marketing Some Important Stone, Pome and Small Fruits and Pine-apples*, 1950, 40; *Rep. Cold Storage & Transport of Perishable Produce in Delhi, Marketing Ser.*, No. 2, 1937, 35; *Rep. Ad Hoc Survey of Cold Storage for Fruits & Vegetables in Consuming Centres in India, Marketing Ser.*, No. 93, 1955, 17; Smock & Neubert, 197–209; Singh, *Indian Fmg*, 1943, **4,** 74; Chandler, 1957, 303).

Among the various storage disorders, soft rot or blue mould, caused by *Penicillium expansum* Thom is responsible for serious losses. The fungus enters the fruit through bruises caused while picking and subsequent handling; it may also gain access to ruptured cells through lenticels, even when the skin is not visibly ruptured. Affected fruits acquire a musty odour and yellowish brown areas appear on the surface. Scrupulous care in picking and handling fruits is essential for preventing infection (Hayes, 387; Singh, *Indian J. agric. Sci.*, 1941, **11,** 902; Butler & Jones, 721–23; Wright & Smith, *Yearb. Agric. U.S. Dep. Agric.*, 1953, 837).

Sooty blotch [*Gloeodes pomigena* (Schw.) Colby] and fly speck [*Leptothyrium pomi* (Mont. & Fr.) Sacc.] mar the appearance of fruits and lower their market value. They are generally found together and are particularly prevalent in low land orchards and in places where humidity remains high and drainage is poor. Sooty blotch appears as dark brown to olive-green spots or smudges on the surface of mature fruits, while fly speck appears as raised small dark spots, commonly in groups. Thinning of fruits

reduces the incidence of infection. Spraying with Bordeaux mixture, Ferbam, lime-sulphur or colloidal sulphur affords effective control. Washing of fruits in a 5% solution of bleaching powder or 3% solution of sodium chlorate is recommended (Singh, *Indian J. agric. Sci.*, 1941, **11**, 597: Groves, *Yearb. Agric. U.S. Dep. Agric.*, 1953, 663).

Phytophthora cactorum (Lebert & Cohn) Schroet., *Aspergillus niger* van Tieghem, *Aspergillus terreus* Thom, *Pestalotia* spp. and *Rhizopus* spp. cause fruit rot of apples. Infection takes place mostly through bruises in the skin or through insect punctures. Storage at 7° reduces damage (Hayes, 387; Dey & Nigam, *Indian J. agric. Sci.*, 1933, **3**, 663; Mehta, ibid., 1939, **9**, 711; Tandon & Tandon, *Proc. nat. Acad. Sci. India*, 1948, **18B**, 17: Tandon & Bhatnagar, ibid., 1958, **28B**, 253).

The apple fruit is subject to a number of physiological disorders during storage. Storage scald results from the accumulation of gases; unblushed or green side of the fruit is first affected and it assumes a characteristic burnt or scalded appearance. Waxing protects the fruits against scalding and also improves the appearance. Oiled paper may be used as wraps for individual fruits: it may be employed in shreds for packing fruits in crates. The use of activated carbon for purifying the air is recommended (Smock & Neubert, 218–22; Chandler, 1957, 300).

Bitter pit, which affects *Baldwin* and some other types, is characterized by the development of brown spots or streaks in the flesh, particularly beneath the skin. Large fruits and immature fruits are more susceptible than others. Heavy doses of nitrogenous fertilizers, excessive shading and heavy pruning are reported to favour pitting. Storage at 32–34°F. under comparatively high humidity affords control (Smock & Neubert, 222–25).

Soft scald affecting certain types, like *Rome Beauty*, *Jonathan*, *Winter Banana* and *Golden Delicious*, is characterized by the appearance of blister-like sunken areas in irregular patterns on the fruit. Storage at or above 36°F. reduces soft scald. Soggy breakdown brown core, mealy breakdown, internal breakdown and Jonathan spot are other disorders affecting apples during storage (Smock & Neubert, 226–35; Chandler, 1957, 301–03).

Fruits develop off-flavours during storage if the oxygen content of the atmosphere is low. Storage of potatoes, onions or cabbage in the same room along with apples, leads to flavour contamination (Smock & Neubert, 242).

Marketing.—Fruits are packed in boxes of standard size, 22 in. × 16 in. × 10 in., in Kashmir and Kumaon; clean straw, pine needles or wood wool is used for lining. In the Punjab hills, boxes of varying sizes holding 40, 20 and 14 lb. are used; before packing, the fruits are wrapped in tissue paper of varying colours; aluminium foil, pliofilm and cellophane are also used. Wrapping should be loose to permit the circulation of oxygen and carbon dioxide. In Bangalore, apples are packed in circular bamboo baskets, 12–16 in. × 8–10 in. (*Bull. Marketing Some Important Stone, Pome and Small Fruits and Pine-apples*, 1950, 26–28, 71; Smock & Neubert, 186; Singh, *Indian Fmg*, 1946, **7**, 574; Kalra, *Punjab Fr. J.*, 1946, **10**, 75; Sukh Dyal, 104–07).

Imports.—Fresh apples are imported into India mainly from Japan and Australia; small quantities of dried apples are also imported (Table 2). India exports fresh apples mainly to Persian Gulf countries; the values of exports were Rs. 9,292 in 1957; Rs. 15,155 in 1958 and Rs. 1,929 in 1959.

Composition and Uses

Apples are valued mainly as dessert fruits. Some types, particularly those with high acid content, are used for culinary purposes. Fruits may be preserved for later use after slicing and drying; they are also canned and jams and jellies are made from them. The juice extracted from the fruits is used fresh or after fermentation into cider, wine and vinegar; apple brandy is obtained by distilling cider (Hill, 389; Smock & Neubert, 21).

Apples are considered valuable as antiscorbutic fruits. They are rich in pectin and are useful in diarrhoea. Apple juice, syrup and vinegar reduce curd tension of milk used in infant feeding. Apple *murraba*, a preserve popular in India, is regarded as a stimulant for the heart; it is reported to relieve physical heaviness and mental strain. The bark of apple trees, particularly the root bark, is considered

TABLE 2—IMPORT OF FRESH AND DRIED APPLES INTO INDIA
(Qty in cwt. and val. in Rs.)

	Fresh fruits from					Dried fruits
	Australia (cwt.)	Japan (cwt.)	Other countries (cwt.)	Total (cwt.)	Total value (Rs.)	Value (Rs.)
1957	18,937	30,049	388	49,374	3,326,707	5,124
1958	7,031	23,669	25	30,725	1,897,631	1,837
1959	114	737	12	863	49,409	8,891

anthelmintic, refrigerant and hypnotic. An infusion of the bark is given in intermittent, remittent and bilious fevers. An antibacterial substance, phloretin (ω-*p*.hydroxyphenyl propiophenone), has been isolated from apple leaves in a yield of 2.4% (dry basis). It inhibits the growth of a number of Gram-positive and Gram-negative bacteria and is active in concentrations as low as 30 p.p.m. Phloridzin is also present in apple shoots, root bark and seeds. Both phloretin and phloridzin produce glucosuria in experimental animals [Schramm, *Acta phytother., Amst.*, 1959, **6**(1), 17; Kirt. & Basu, II, 987; Smock & Neubert, 265–67; Parpia *et al.*, 16; MacDonald & Bishop, *Canad. J. Bot.*, 1952, **30**, 486; *Indian J. Pharm.*, 1950, **12**, 126].

Apple wood (wt., 48 lb./cu.ft.) is strong, hard and compact. It stands seasoning well, but is susceptible to warping and splitting. It can be used for tool handles, pipes, knobs, mallet heads, rulers, canes and turnery (Howard, 31; Hill, 106).

Chemical composition The composition of the apple fruit varies with variety, climatic conditions during the growing season, and the stage of maturity. The analytical values fall within the following ranges: total solids, 13.6–26.0; total sugars (as invert sugar), 9.5–17.4; glucose, 2.5–5.6; fructose, 6.5–11.8; sucrose, 1.5–6.0; acids (as malic acid), 0.3–1.0; and tannin, 0.02–0.15%. The compositions of some varieties of apples from Kashmir are given in Table 3. The vitamins, salts and organic acids are concentrated particularly in and just below the skin and the fruit should be eaten unpeeled [Jacobs, II, 1495–97; Winton & Winton, II, 565; Pruthi *et al.*, *Food Sci.*, 1960, **9**, 363; Schramm, *Acta phytother., Amst.*, 1959, **6**(1), 17].

TABLE 3—CHEMICAL COMPOSITION OF THE FLESH OF SOME IMPORTANT VARIETIES OF APPLES FROM KASHMIR*

	Ambri Kashmiri	Golden Delicious	Red Delicious	Red Pippin	Yellow Pippin
Total solids, %	18.07	12.30	15.82	16.57	17.57
Acidity (as malic acid), %	0.63	0.73	0.58	0.55	0.59
Reducing sugars, %	10.09	5.45	7.22	8.80	8.20
Non-reducing sugars, %	2.10	1.55	1.86	2.38	2.61
Total astringency, %	0.13	0.10	0.09	0.11	0.13
Protein, %	0.38	0.11	0.06	0.07	0.30
Crude fibre, %	1.60	1.51	1.47	1.72	1.85
Ash, %	0.34	0.26	0.22	0.35	0.33
Calcium, mg./100 g.	9.78	16.00	10.15	19.50	16.58
Phosphorus, mg./100 g.	12.02	18.18	18.18	16.94	8.16
Iron, mg./100 g.	1.34	0.86	0.86	0.52	1.11
Ascorbic acid, mg./100 g.	7.52	7.45	8.86	8.61	5.84

* Pruthi *et al.*, *Food Sci.*, 1960, **9**, 363.

Sugars constitute *c.* 80% of the total carbohydrates of ripe fruits. Fructose is the principal component (*c.* 60%), followed by glucose (25%) and sucrose (15%). Arabinose, xylose, sorbitol, a cyclitol (probably *meso*-inositol), and two ketose oligosaccharides are present in minor quantities. Other carbohydrates present are starch, dextrins, pectic substances, cellulose, hemicellulose and pentosans. Starch and dextrins are almost completely hydrolysed into sugars during the maturation of fruits after harvest; a part of the hemicellulose is also transformed into sugars. The cellulose content, however, remains almost constant while there is a gradual decline in the amount of pentosans. Ripe and mature apples contain (av. values): pentosans, 0.50; lignin, 0.40; and cellulose, 0.90% (Hills & Willaman, *Yearb. Agric. U.S. Dep. Agric.*, 1950–51, 256; Siddappa & Bhatia, *Indian J. Hort.*, 1954, **11**, 19; Ash & Reynolds, *Aust. J. Chem.*, 1955, **8**, 276; Smock & Neubert, 56–61, 112; Jacobs, II, 1495–97; Winton & Winton, II, 565).

The pectin content of the edible portion of eating and cooking apples varies from 0.14 to 0.96% (as calcium pectate). The pectin content of the peel is higher than that of the flesh and during the ripening of the fruit, protopectin is changed into soluble pectin. The amount of total pectic materials remains fairly constant until the apples become over-ripe and mealy, when soluble pectic substances break down into non-pectic constituents. The uronic acid content of apple pectin varies from 0.5 to 15% (Kertesz, 286–87; Money & Christian, *J. Sci. Fd Agric.*, 1950, **1**, 8; *Biol. Abstr.*, 1948, **22**, 173).

Attempts to isolate proteins from apples have yielded an impure material (N content, 8.5%) contaminated with polysaccharides, tannin-like compounds, etc. A small quantity of nucleo-protein is probably present. The non-protein fraction of the ripe fruit contains free amino acids, amides, ammonia nitrogen and basic nitrogen. Asparagine accounts for 50% of the non-protein nitrogen present in mature fruits; proteoses and polypeptides are present in small amounts. Several free amino acids, including pipe-

colinic acid, γ-methyl proline and 4-hydroxy-methyl-proline, have been identified in the alcoholic extracts of the fruit (Smock & Neubert, 66–67; Davis *et al.*, *Food Res.*, 1949, **14,** 417; McKee & Urbach, *Aust. J. biol. Sci.*, 1953, **6,** 369; Hulme & Arthington, *Nature, Lond.*, 1954, **173,** 588; Urbach, ibid., 1955, **175,** 170).

The vitamins present in the edible portion of fresh apples are: thiamine, 0.12; riboflavin, 0.03; niacin, 0.2; and ascorbic acid, 2 mg./100 g.; carotene, pantothenic acid, pyridoxine, biotin, inositol and folic acid are present in small amounts. The ascorbic acid content varies widely and values up to 40 mg./100 g. have been reported in certain varieties; dehydroascorbic acid is present in appreciable amounts and in most varieties, its concentration exceeds that of ascorbic acid. There is a considerable loss of the acid during storage (*Hlth Bull.*, No. 23, 1951, 44; *Misc. Bull. U. S. Dep. Agric.*, No. 572, 1945; Cheldelin & Williams, *Univ. Tex. Publ.*, No. 4237, 1942; Jacobs, II, 1496, 1523; *Chem. Abstr.*, 1951, **45,** 6315).

Malic acid is the principal acid (90–95% of the total acids) of the fruit; citric, lactic and succinic acids are present; other acids reported to be present in traces are oxalic, formic, acetic, dihydroxy-tricarballylic, *l*-quinic, glycolic, caffeic, coumaric and *n*-coumaryl quinic acids. Stored apple juice (45 days at 19–20°) contains propionic and butyric acids. Shikimic acid occurs in the peel and its concentration increases with the ripening of fruit (Smock & Neubert, 61–64; Jacobs, II, 1518; Hulme & Swain, *Nature, Lond.*, 1951, **168,** 254; *Chem. Abstr.*, 1954, **48,** 10951; 1955, **49,** 1236; 1956, **50,** 17241; Cartwright *et al.*, *Chem. & Ind.*, 1955, 1062; Hulme, *Nature, Lond.*, 1956, **178,** 991).

The wax-like coating on the surface of apples is soluble in ether and contains ursolic acid, an oily fraction (iod. val., 80–140) and a waxy fraction. The oily fraction increases at a faster rate than ursolic acid during the ripening and storage of fruit: it contains: fatty acids, 70–85%; and unsapon. matter, 15–30%. The waxy fraction contains: nonacosane, heptacosane, *d*-10-nonacosanol, triacontanol, octacosanol and hexacosanol. The ether-insoluble fraction of the cuticle, referred to as cutin, is a lipide material consisting mainly of complex hydroxy acids (Markley & Sando, *J. agric. Res.*, 1931, **32,** 705; Chibnall *et al.*, *Biochem. J.*, 1931, **25,** 2095; Huelin & Gallop, *Aust. J. sci. Res.*, 1951, **4B,** 526).

A yellowish, somewhat viscid essential oil, possessing the fragrance of fresh apples is obtained in 0.0035% yield by ether extraction of aqueous distillates of *Ben Davis* apple parings. It consists mainly of amyl esters of formic, acetic and caproic acids together with caprylic ester, geraniol and acetaldehyde. Analysis of apple essence (obtained from the juice of *McIntosh* and *Stayman Winesap* apples in 25 p.p.m. yield) gave the following values: alcohols (methanol, ethanol, propanol, 2-propanol, butanol, *d*-2-methyl-butanol, hexanol), 92; carbonyl compounds (acetaldehyde, acetone, caproaldehyde and 2-hexenal), 6; and esters (ethyl butyrate and ethyl caproate), 2%; esters of methanol, ethanol, 2-propanol and butanol with formic, acetic, propionic, butyric and caproic acids have also been identified. Essences prepared from the different varieties of apples vary greatly both in quality and quantity (Power & Chesnut, *J. Amer. chem. Soc.*, 1920, **42,** 1509; 1922, **44,** 2938; White, *Food Res.*, 1950, **15,** 68; Griffin *et al.*, *Fruit Prod. J.*, 1947, **27,** 4).

The astringent principles of apple include tannins, tannin derivatives and colouring materials (flavones). The concentration in which they occur vary according to variety, season and stage of maturity of the apple. Green fruits are rich in tannins (caffetannin, *d*-catechin and *l*-epicatechin); the concentration decreases rapidly as the fruits mature on the tree. The browning of apple slices on exposure to air is due to the enzymic oxidation of tannin compounds. The relative proportion of astringents, sugars and acids in the fruit determines its flavour and eating quality (Smock & Neubert, 74–76; Johnson *et al.*, *Food Technol., Champaign*, 1950, **4,** 237; Nakabayashi, *J. agric. chem. Soc. Japan*, 1952, **26,** 813).

The green colour of the peel of immature apples is due to chlorophyll. As the fruit matures on the tree, the colour changes into yellow or red or both. Several factors, such as the amount of sugars, leaf fruit ratio, sunshine and supply of water govern the formation of yellow and red pigments. The principal yellow colouring matter is a flavone glycoside, hyperin (3-galactosidyl quercetin). An anthocyanin, idaen (3-galactosidyl cyanidin), has been identified as the pigment mainly responsible for the red colouration; several varieties of Indian apples with red peels contain malvidin monoglycoside. The skin of *Grimes Golden* apples contains six quercetin glycosides, viz. hyperin, avicularin, quercitrin, *iso*-quercitrin, rutin and quercetin 3-xyloside (Smock & Neubert, 77–82; Sharma & Seshadri, *J. sci. industr. Res.*, 1955, **14B,** 213; Siegelman, *J. biol. Chem.*, 1955, **213,** 647).

Diastase, oxidases (polyphenolase, peroxidase and ascorbidase) and catalase are present in fairly high concentrations in apple tissue. The oxidase activity decreases with the maturity of fruit. The catalase activity is highest in the skin and least in the region immediately beneath the skin. High metabolic activity of tissues is usually characterized by a high catalase activity. The polyphenolase is responsible for the darkening of apples. Ascorbidase, which converts ascorbic acid into dehydro-ascorbic acid, is reported to be present in high amount in Indian apple (Smock & Neubert, 83–88; Babbar, *Indian J. med. Res.*, 1950, **38,** 263).

An esterase which breaks down ethyl malonate, small amounts of protease of the trypsin or papain type, invertase (opt. *p*H, 4), pectin demethoxylase or pectase (opt. *p*H, 6.6), arabinase, galactanase and polygalacturonase are among the other enzymes identified in the apple. The pectase content varies markedly according to the variety and stage of maturity (Smock & Neubert, 89; *Chem. Abstr.*, 1953, **47,** 173; Pollard & Kieser, *J. Sci. Fd Agric.*, 1951, **2,** 30; Ozawa & Okamoto, *Rep. Ohara Inst. agric. Res.*, 1952, **40,** 103).

Apple is considered a good source of potassium. The edible portion of fresh apples contains: calcium, 6; magnesium, 6; potassium, 111; sodium, 2; phosphorus, 11; chlorine, 4; sulphur, 5; and iron 0.3 mg./100 g.; copper (85 μg./100 g.), manganese, aluminium, zinc, iodine, boron, lead and arsenic are present in traces. The mineral constituents of the apple are considered valuable for human nutrition (Sherman, 682; Smock & Neubert, 68–70; Bagchi & Chowdhury, *Ann. Biochem.*, 1949, **9,** 107; Timberlake, *Rep. agric. hort. Res. Sta., Bristol*, 1951).

Apples contain small amounts of phosphatides, including lecithin. The unripe fruit contains calcium oxalate which disappears with ripening. Ethylene has been identified among the gases evolved during the storage of ripe fruits. The temperature of storage has a marked effect on the evolution of ethylene. More ethylene is given off by dessert varieties than by culinary varieties. In addition to ethylene, traces of acetaldehyde, ethyl alcohol, acetone, esters of amyl and other alcohols are also formed. Some of the volatile products are toxic and tend to cause damage to stored apples (Jacobs, II, 1524, 1515–16; Thorpe, I, 451; *Chem. Abstr.*, 1951, **45,** 220; Thompson, *Aust. J. sci. Res.*, 1951, **4B,** 283; Huelin, ibid., 1952, **5B,** 328).

Apple seeds—The seeds obtained as a by-product from processing plants contain 0.62–1.38% amygdalin (HCN equivalent, 0.037–0.082%) and yield 18–23% of a bright yellow, semi-drying oil with an agreeable odour of bitter almonds. The oil has the following characteristics: sp. gr.$^{20°}$, 0.902–0.923; $n_D^{40°}$, 1.466–1.468; acid val., 0.9–3.0; sap. val., 186–197; iod. val., 119–123; hydroxyl val., 9; R.M. val., 0.2–1.0; Polenske val., 0.4–0.5; and unsapon. matter, 0.8–1.8%. The oil is of little economic importance as it is available in very limited quantities (Eckey, 460; Winton & Winton, II, 581; Jacobs, II, 1523).

Apple Products

Dried apples & Apple powder—Dehydrated apples (moisture content, 3% or less), apple flour or powder, and dried apples (moisture content, $\not>$ 24%) in the form of rings, chops and sauces are available in commerce. Dried apples find use in bakeries; apple flour is used in the treatment of certain types of infant diarrhoea (Smock & Neubert, 274–76).

For dehydration, fruits which are relatively rich in acid content, good flavour and firm texture are preferred. *Ambri, Golden Delicious, Red Pippin* and *Yellow Pippin* are satisfactory for the purpose. Peeled fruits are cored, cut into segments, and steam-blanched or exposed to sulphur fumes to prevent browning; they are then spread on trays and dried in a kiln or tunnel drier at 140–175°F. Vacuum shelf driers are used to obtain a product of superior quality. The dehydrated product contains: water, 1.6; protein, 1.4; fat, 1.0; total carbohydrates, 90.1; fibre, 3.8; and ash, 2.0%; calcium, 24; phosphorus, 42; and iron, 4.1 mg./100 g.; ascorbic acid, 9; thiamine, 0.02; riboflavin, 0.04; and niacin, 0.5 mg./100 g. (Saxena *et al.*, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1955–56, **5,** 241; Smock & Neubert, 287–96; Pavcek *et al.*, *Industr. Engng Chem.*, 1946, **38,** 853).

Canned & frozen apple—Canned apples are usually available in large packings and are used in pies. Apple segments are preserved by dehydrofreezing which involves partial drying of prepared fruit to *c.* 50% moisture and subsequent freezing (Girdhari Lal *et al.*, 60; Smock & Neubert, 296–310).

Apple juice—*Yellow Newton* and *Baldwin* types from Kulu are generally favoured for the production of apple juice. Ripe and sound fruits are pressed out in basket type or rack-and-cloth presses. The yield of juice varies from 150–180 gal. per ton of fruit. The juice is strained through a thin layer of cotton wool or coarse muslin cloth and bottled after

pasteurization. For preparing a product with good flavour, juices from several apple varieties are blended. Prior treatment of freshly extracted juice with pectin decomposing enzymes (Filtragol or Pectinol), kaolin, or gelatin-tannin gives a clear product (Girdhari Lal *et al.*, 128; Lal Singh & Girdhari Lal, *Misc. Bull., Indian Coun. agric. Res.*, No. 39, 1940; Jacobs, III, 2198).

Fresh apple juice is an amber coloured fluid with a mild, delicate flavour. Analysis of juices from 19 varieties of apples grown in Kulu gave the following ranges of values: total solids, 10.07–15.24° Brix at 63°F.; sp. gr., 1.038–1.061; acidity (as malic acid), 0.20–0.80%; and tannin, 0.021–0.080%. Fresh juice from *Baldwin* apples contains 11.06% total sugars. Apple juice is a popular beverage. Its ingestion increases the acidity of gastric juice. It is recommended for the treatment of diarrhoea and peptic ulcers. Apple juice concentrates are prepared by evaporation of the fruit juice at low temperature; they are used in the manufacture of fruit beverages, jams and jellies. Apple syrups are obtained from deacidified juice by concentration. They find use in beverages, ice cream, candy and bakery products. They are used also in infant feeding for reducing curd tension in milk and as a source of carbohydrates (Lal Singh & Girdhari Lal, loc. cit.: *Food Sci.*, 1959, **8**, 327; Smock & Neubert, 267, 329, 366, 375–76; Magee, *Food Manuf.*, 1952, **27**, EAL; *Chem. Abstr.*, 1954, **48**, 1496; Jacobs, III, 2203; Buck & Mottern, *Industr. Engng Chem.*, 1945, **37**, 635).

Apple cider—Cider is obtained by the alcoholic fermentation of apple juice; it contains 0.5–8% (av. 5.5%) alcohol. Fresh filtered juice (from apples with high tannin content) is inoculated with a pure culture of wine yeast after adding potassium metabisulphite (1.5 grains/lb. juice) and ammonium hydrogen (phosphate (0.02–0.05%); sucrose is added to raise the density to 22° Brix. The temperature is maintained at 65–70°F. and when the fermentation is complete, the clear liquor is separated from the yeast sediment and aged in oak casks. It is then carbonated and bottled. Large quantities of cider are also produced by fermentation of fresh juice with yeasts naturally associated with apples (Smock & Neubert, 378, 388; Jacobs, III, 2422; *Brochure on Home-scale Food Preparation Series*, Cent. Fd technol. Res. Inst., Mysore, No. 28, 1959).

Apple wine—Apple wines are classified on the basis of their alcohol and sugar contents. Wines containing not more than 14% alcohol are produced by the fermentation of a mixture of apple juice and sugar; those with higher alcohol content are prepared by adding apple brandy. The alcohol content of wine may be increased also by freezing. Apple wine is filtered and aged for 2–3 months in tanks or casks (preferably oak casks) to produce a mellow spirit with pleasant flavour and aroma (Smock & Neubert, 403–06).

Apple brandy—Apple brandy is obtained by distilling clarified cider in pot stills. The first distillation yields a product containing *c.* 30% alcohol; it is redistilled to give brandy with 55–67% alcohol content. High-proof brandies containing up to 95% alcohol are obtained by continuous distillation of cider in a series of pot stills. Apple brandy is aged in oak casks until mellow and filtered before bottling. Fruits and cider of inferior quality, and wastes from apple-processing plants are utilized for the production of brandy. Yields of 10.7–12.6 gal. of 95% alcohol per ton of apples have been reported (Smock & Neubert, 406–08).

Surplus and waste apples may be utilized for the production of industrial alcohol. *Torulopsis utilis* may be grown in apple juice media using ammonium sulphate and ammonium hydroxide as nitrogen sources; a yield of 42 g./100 g. sugar has been obtained. Gluconic acid is obtained by fermentation of apple juice using *Penicillium citrinum* as inoculum (Smock & Neubert, 410, 417).

Apple jam & murraba—Peeled fruits, freed from core, are used for the preparation of jam. The material is cut into pieces and cooked with water until soft; sugar is then added and cooking continued until the soluble solids content reaches *c.* 68%.

Apple murraba (preserve) is prepared from firm fruits which are peeled, cored and cut into sections. The pieces are blanched in hot water containing sodium bisulphite; lime water or alum is added as a firming agent. The pieces are pricked all over and cooked with sugar syrup (36–38° Brix) to which a small quantity of citric acid has been added. The finished product (strength of syrup, 70° Brix) is cooled before packing (Smock & Neubert, 432–33; Girdhari Lal *et al.*, 180).

The proximate compositions of fruit segment and syrup in a sample of apple *murraba* after storage for 40 weeks at 24–30°, were as follows: *fruit segment*—moisture, 27.88; ether extr., 0.12; protein, 0.09; acidity (as citric acid), 0.13; reducing sugars (as invert sugar), 32.62; total sugars (as invert sugar), 64.00; crude fibre, 0.64; and ash, 0.25%: calcium, 130.80;

phosphorus, 6.14; and iron, 2.80 mg./100 g.: *syrup*—moisture, 27.58; ether extr., 0.04; protein, 0.02; acidity (as citric acid), 0.13; reducing sugars (as invert sugar), 32.51; total sugars (as invert sugar), 65.52; crude fibre, 0.17; and ash, 0.29% (Bhatia & Siddappa, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1955–56, **5,** 238).

Apple butter Apple butter is a smooth, semi-solid material prepared by cooking the fruits with water until soft, followed by screening. The pulp is mixed with sugar or apple juice and the mixture concentrated until the desired consistency is attained (soluble solids, ≮ 43%). Spices or other flavourings may be added *c.* 10 min. before the completion of cooking (Smock & Neubert, 434; *Campbell's Book*, Vance Publishing Corporation, Chicago, 1950, 105).

Apple pomace—Apple peel and core, obtained as wastes during the manufacture of apple products, are dried for use as a source of pectin or as animal feed. The dried material may be stored for years without deterioration. Analysis of dried apple pomace gave the following values: moisture, 11.0–12.5; N-free extr., 54.77–59.29; pectin, 15.0–18.0; crude fibre, 15.35–20.55; protein, 4.45–5.67; fat (ether extr.), 3.75–4.65; and ash, 2.11–3.50%. It may be fed to animals as such or after ensiling. The average nutritive values of dry and ensiled apple pomace are as follows: *dry pomace*—moisture, 10.4; protein, 4.3; digestible protein, 1.6; and total digestible nutrients, 64.5%; nutritive ratio, 39.3; *ensiled pomace*—moisture, 79.1; protein, 1.6; digestible protein, 0.6; and total digestible nutrients, 14.3%; nutritive ratio, 32.8. The silage is usually fed to milch cows after milking to avoid off-flavour in milk. Dried pomace is used as a carrier for insect baits. Special preparations of the pomace are useful as diet supplements to patients suffering from colic and gastritis (Hills & Willaman, *Yearb. Agric. U. S. Dep. Agric.*, 1950–51, 256; Smock & Neubert, 439–43, 450; Morrison, 551, 1036, 1044; *Chem. Abstr.*, 1955, **49,** 12747).

Apple pectin—Dried apple pomace is ground and leached with water to remove soluble matter. The residue is extracted for 1 hr. with boiling acidulated water (*p*H, 2.8–3.2) containing polyphosphates. The extract is pressed out, centrifuged after standing and concentrated under vacuum. The concentrate (pectin content, 3–5%) may be used as such or dried into powder in spray or drum driers. Alternatively, the pectin may be precipitated by alcohol or aluminium salts (Smock & Neubert, 447–48; Kertesz, 450).

The residue remaining after pectin extraction is used as animal feed. The dried residue (digestible protein, 2.6%; total digestible nutrients, 62.4%; and nutritive ratio, 23.0) is not relished by dairy cows and should be fed along with palatable concentrates (Morrison, 551, 1042).

MALVA Linn. (*Malvaceae*)

A genus of herbs and shrubs, popularly known as Mallows, distributed chiefly in the temperate regions of the Old World; some species have become naturalized in North America. About 5 species are found in India.

M. parviflora Linn.

D.E.P., V, 141; Fl. Br. Ind., I, 321.

Hindi—*Panirak.*

Punjab—*Gogisag, nanna, sonchal, supra.*

A spreading pubescent herb, 15–45 cm. high, distributed over the greater part of India. Leaves sub-orbicular, cordate; flowers purplish or white; fruits round, flattened; seeds black, glabrous.

The plant is used as a pot-herb; green fruits are also eaten. In Mexico, the plant is cooked like spinach, which it resembles in taste, though more fibrous. It is a rich source of calcium, iron and carotene. An analysis of the Mexican plant gave the following values: moisture, 85.9; nitrogen, 0.94; and ash, 2.6%: calcium, 312; phosphorus, 73; iron, 19.5; carotene, 2.53; thiamine, 0.11; riboflavin, 0.19; niacin, 0.95; and ascorbic acid, 45.4 mg./100 g. (Neal, 484; Cravioto *et al.*, *J. Nutr.*, 1945, **29,** 317).

The plant is considered emollient and pectoral. An infusion of the leaves is taken as a nerve tonic in South Africa. A decoction of the leaves is used as a taenicide and as a lotion for bruises; leaves are also used for poulticing wounds and swellings. The seeds are demulcent and used in cough and ulcers in the bladder; they yield 18% of a fatty oil (iod. val., 98–99). In Kumaon, the root is said to be used for cleansing hair and washing woollen clothes (Kirt. & Basu, I, 303; Eckey, 663; Watt & Breyer-Brandwijk, 117; Chopra *et al.*, 236).

The plant is considered poisonous to livestock: animals develop spasms if they are worked or driven soon after feeding on the plant; the symptoms are stiff gait, repeated falling and struggling to rise and trembling or shivering, particularly in shoulders and hind quarters. Many cases of 'staggers' in sheep have been recorded in Australia; cattle and horses are also susceptible. Lambs are liable to staggers from

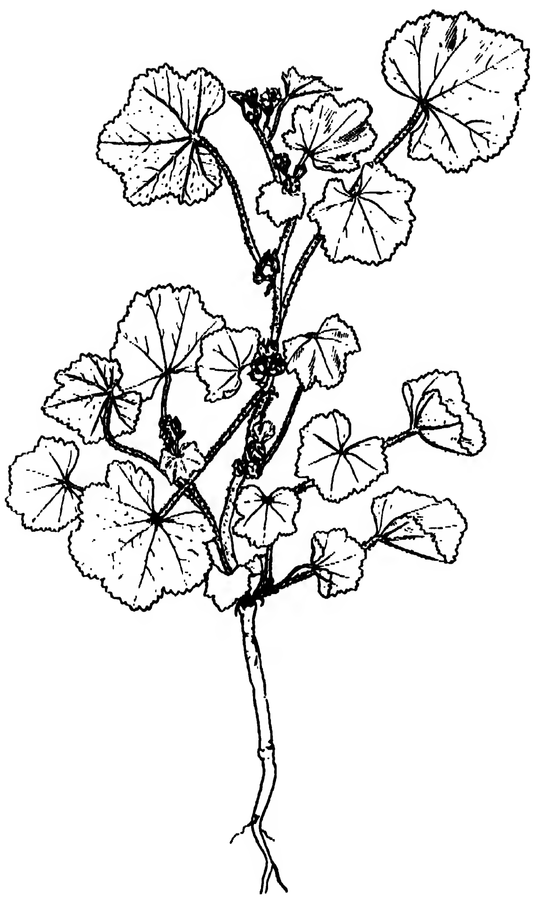


FIG. 87. MALVA PARVIFLORA—FLOWERING BRANCH

the milk of the ewe. Rest and change of diet ensure recovery but no immunity can be built up. The plant also causes 'pink-white' in hen's eggs; an unsaturated fatty acid, malvalic acid ($C_{18}H_{32}O_2$), present in the fatty oils from the leaves and seeds of the plant, is responsible for the pink-white disease. Malvalic acid possesses strong surface active properties; the potassium salt of the acid enhances the haemolysis of sheep erythrocytes (Chopra *et al.*, 236–37; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 103; Connor, *Bull. Dep. sci. industr. Res. N.Z.*, No. 99, 1951, 46; Shenstone & Vickery, *Nature, Lond.*, 1956, **177,** 94; Macfarlane *et al.*, ibid., 1957, **179,** 830).

M. rotundifolia Linn.

D.E.P., V, 141; Fl. Br. Ind., I, 320; Kirt. & Basu, Pl. 117.

Hindi—*Khubasi;* Tel.—*Trikalamalli;* Kan.—*Kadukadalegida.*

Bombay—*Khaparkuti, chandiri.*

A much-branched sparingly pubescent herb found in Simla and Kumaon; it is also recorded from the plains of North India and Deccan. Leaves suborbicular; flowers pale purple or white; fruit olive-brown with brown black seeds.

The plant is reported to be used as a pot-herb; tender shoots are eaten as salad. It is also used as fodder. The air-dried plant contains: nitrogen, 0.41–0.42; ash, 17.25–17.45; and water-soluble extractives, 40.0%; leaves contain 117.5 mg./100 g. of ascorbic acid. Other constituents isolated from the plant include a fatty oil containing oleic, stearic and palmitic acids, a wax which is primarily octacosane, a phytosterolin, arabinose, potassium nitrate, potassium chloride, calcium sulphate, mucilage and resins (*Nutr. Abstr. Rev.*, 1958, **28,** 1093; Curts & Harris, *J. Amer. pharm. Ass., sci. Edn*, 1949, **38,** 470; Medsger, 165).

The dried leaves of *M. rotundifolia* and *M. sylvestris* yield the pharmacopoeial drug Malvae Folia or Mallow Leaves, used as demulcent and emollient. *M. rotundifolia* is used in glycosuria and stomach disorders and as emmenagogue. It is used also in fomentations and poultices for relieving sore throat and ophthalmia and for maturing abscesses. Seeds are demulcent and are prescribed in bronchitis, cough, inflammations of the bladder and haemorrhoids; they contain 7–8% of a fatty oil (iod. val., 98–99). Flowers contain tannin (Gathercoal & Wirth, 96; Merck Index, 596; Kirt. & Basu, I, 302; Chopra, 1958, 598, 625; Curts & Harris, loc. cit.; Eckey, 663; Hocking, 134; Watt & Breyer-Brandwijk, 117).

M. sylvestris Linn.

D.E.P., V, 141; Fl. Br. Ind., I, 320; Kirt. & Basu, Pl. 117.

Hindi—*Gulkhair, kunzi, vilayatikangai.*

Bombay—*Khubasi;* Kashmir—*Khalazi.*

An erect, branched, woody biennial or perennial, 30–120 cm. high, found from Kashmir to Kumaon up to an altitude of 2,400 m., and in Bihar and parts of the Deccan Peninsula, mostly as a weed. It is also cultivated in gardens. Leaves 3–7 lobed, on long stalks; flowers purple; fruit smooth; seeds reniform.

The leaves are eaten as a vegetable; young carpels and seeds are also eaten. An analysis of the leaves from Mexico gave the following values: moisture, 92.0; nitrogen, 0.33; and ash, 1.7%: calcium, 221; phosphorus, 36; iron, 9.7; carotene, 4.8; thiamine, 0.10; riboflavin, 0.24; and niacin, 0.44 mg./100 g.

The plant is a good source of carotene and calcium; ascorbic acid is present in appreciable amounts (Cravioto *et al.*, *J. Nutr.*, 1945, **29**, 317; *Chem. Abstr.*, 1938, **32**, 6336; Brimble, 120; Medsger, 165).

All parts of the plant are rich in mucilage. The herb possesses demulcent, cooling, antiseptic and emollient properties. It is used in pulmonary and urinary affections and also in external applications for abscesses and inflammations. Flowers and immature fruits are used for whooping cough; they are official in French and Swiss pharmacopoeias; leaves are official in Swiss pharmacopoeia (Kirt. & Basu, I, 301; Chopra, 1958, 598; Caius, *J. Bombay nat. Hist. Soc.*, 1942–43, **43**, 495).

An extract of the leaves stimulates the smooth muscles of isolated uterus and intestines; the active principle is present to the extent of 0.018% in the leaves. Flowers are used for colouring wine red. The colouring matter of the flowers is a diglucoside, malvin ($C_{29}H_{35}O_{17}$, m.p. 165°) (Wehmer, II, 757; *Chem. Abstr.*, 1946, **40**, 1589; Steinmetz, II, 288; McIlroy, 57).

M. verticillata Linn.

D.E.P., V, 143; Fl. Br. Ind., I, 320.

BENG.—*Lapha, napha.*

ASSAM—*Laffa.*

A hairy herb, 30–120 cm. high, found in temperate Himalayas from Punjab eastwards to Assam, ascending up to an altitude of 3,600 m., and in Nilgiri hills. Leaves long-stalked, cordate, downy; flowers pink, crowded, in clusters.

The herb is eaten as a vegetable in Assam, where it is grown as a cold weather crop. Seeds are sown in November and leaves harvested in February. The plant is used as animal feed as such or after ensilage. Malvalic acid has been identified in the oils from leaves and seeds [Carter & Carter, *Rec. bot. Surv. India*, 1921, **6** (9), 395; *Chem. Abstr.*, 1938, **32**, 5039; Shenstone & Vickery, *Nature, Lond.*, 1956, **177**, 94; Macfarlane *et al.*, ibid., 1957, **179**, 830].

The root of *M. verticillata* is used for whooping cough in Indo-China. The ash of dried leaves is given in scabies (Kirt. & Basu, I, 304).

MALVASTRUM A. Gray (*Malvaceae*)

A genus of herbs and shrubs found chiefly in America and Africa; a few species are widely distributed throughout the tropics of the world. Two species have been recorded in India.

M. coromandelianum Garcke syn. *M. tricuspidatum* A. Gray

Fl. Br. Ind., I, 321; Mudaliar & Rao, Pl. 38.

An erect or ascending herb or an undershrub, up to 90 cm. in height, with ovate-lanceolate leaves and yellow flowers found as a weed in waste places and cultivated fields throughout the greater part of India.

The weed may be controlled by grubbing the surface of the soil or by pulling out the plants. Application of 0.2% MCPA (methyl chlorophenoxy acetic acid) is also said to be helpful [Mudaliar & Rao, 99; Ram Gopal, *Indian Fmg, N.S.*, 1954–55, **4** (10), 23].

The plant is considered to possess bechic, emollient and resolvent properties. A decoction of the plant is given in dysentery. The leaves are applied to inflamed sores and wounds as a cooling and healing salve and flowers are given as a pectoral and diaphoretic. The plant apparently shows no antibacterial properties. The stems yield a fibre and are used for making brooms (Kirt. & Basu, I, 305; Brown, 1941, II, 422; Fl. Assam, I, 141).

M. americanum Torr. syn. *M. spicatum* A. Gray is a weed, up to 60 cm. in height, found in various parts of India. It is said to be poisonous to sheep. The plant contains 0.5–2.5% total oxalate (calculated as oxalic acid) and possibly an alkaloid (Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 103; *Chem. Abstr.*, 1954, **48**, 14037; Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 241, 1949, 34).

*MAMMEA Linn. emend. (*Guttiferae*)

A small genus of trees distributed in tropical Asia, Africa and America. Three species have been recorded in India, including *M. americana* introduced from America.

M. americana Linn. MAMMEY APPLE

Bailey, 1947, II, 1975, Fig. 2313.

A small or moderate-sized, slow growing tree, 12.0–18.0 m. or more in height, native of West Indies, and widely cultivated throughout tropical America and other parts of the world including India. Flowers white, fragrant, borne singly or in clusters; fruits reddish green or russet, globose, c. 15.0 cm. in diam., with thick leathery outer skin;

* The Asian species are usually assigned to the genus *Ochrocarpus* Thouars; recent authorities, however, feel the two genera should be united, there being no constant characters or correlation of characters by which they could be distinguished (De Wilde, *Acta bot. neerl.*, 1956, **5**, 171).

seeds 1–4 embedded in an orange coloured, sweetish, aromatic pulp.

The tree prefers a rich well-drained soil and can be propagated by seeds. It grows well in Calcutta and yields a plentiful crop of fruits (Record & Hess, 183; Popenoe, 403; Firminger, 245).

The fruit is eaten raw or stewed. It can be cut into slices and served with wine and sugar or preserved in syrup. The pulp is used also in jams and sauces. In West Indies, an aromatic liquor called *Eau-de-Creole*, is distilled from the flowers and used for flavouring purposes (Popenoe, 403; Chandler, 311).

Analysis of the edible portion (62%) of the fruit gave the following values: water, 86.5; protein, 0.6; fat, 0.3; total carbohydrates, 12.3; fibre, 1.5; and ash, 0.3%: calcium, 13 mg.; iron, 0.4 mg.; vitamin A, 280 i.u.; thiamine, 0.02 mg.; riboflavin, 0.04 mg.; niacin, 0.5 mg.; and ascorbic acid, 15 mg./100 g. Citric acid (0.6%), sucrose (5.5%) and reducing sugars (3.9%) are present; the ash is alkaline (Chatfield, *FAO nutr. Stud.*, No. 11, 1954, 38, 49; Winton & Winton, II, 781).

The seeds which are bitter and resinous are highly toxic to several insect pests, including cockroaches, mosquitoes and flies. An infusion of the seeds in water is effective against lice and fleas on animals and human beings; that of the fruit pulp (1 lb. of pulp in 1 gal. of water) is as efficacious as 1% DDT suspensions in controlling ticks and fleas in dogs, but somewhat less effective in resisting reinfestation. The gummy sap of the thick rind and developing seeds of half-ripe fruit are also active; seed hulls are inert; the bark shows feeble activity, but the leaves are more potent, though less active than seeds. Powdered mature seeds retain their insecticidal activity indefinitely and can be employed in the form of dust or spray. Aqueous extracts of the bark are useful as tick-washes (*Hort. Abstr.*, 1952, **22,** 95; Plank, *Trop. Agriculture, Trin.*, 1950, **27,** 38; *Chem. Abstr.*, 1945, **39,** 2617; 1951, **45,** 4394).

The insecticidal activity of the seeds resides in the resinous matter. Extraction of seed powder with petroleum ether yields a sticky semi-solid mass from which a crystalline compound ($C_{18}H_{22}O_4$, m.p. 130–31°) and an amorphous substance (softening at 170–75°) have been separated; the latter accounts for 74% of the activity of the original extract and is 20% as toxic as rotenone. The seed extract contains antibiotic substances which are active *in vitro* against certain bacteria. The seeds yield a fixed oil (iod. val., 19.3) suitable for use in cosmetics and pharmaceutical preparations. The wood of *M. americana* is reddish brown, hard and durable; it is fairly straight-grained, and medium-textured and takes good polish. It is suitable for cabinet work (*Hort. Abstr.*, 1952, **22,** 95; Morris & Pagan, *J. Amer. chem. Soc.*, 1953, **75,** 1489; *Chem. Abstr.*, 1938, **32,** 9534; Record & Hess, 183; Burkill, II, 1399).

M. longifolia Planch. & Triana syn. *Ochrocarpus longifolius* Benth. & Hook. f.

D.E.P., V, 439; Fl. Br. Ind., I, 270; Kirt. & Basu, I, 269, Pl. 105.

SANS.—*Nagakesara*; HINDI—*Nagkesar*; BENG.—*Nagesar*; MAR.—*Punnag, suringi*; GUJ.—*Ratinagkesar*; TEL.—*Suraponna*; TAM.—*Nagappu, nagesarpu*; KAN.—*Wundi, suragi, gardundi*; MAL.—*Seraya*; ORIYA—*Churiana*.

A large tree with a cylindrical trunk, 12–18 m. high and 1.8 m. in girth, found in the evergreen forests of western India from Khandala southwards to Malabar and Coimbatore, ascending to an altitude of 600 m. Leaves broadly ovate, thickly coriaceous; flowers globose in bud, white or pinkish, sweet scented, in dense fascicles; fruits *c.* 2.5 cm. long, obliquely ovoid, enclosing 1–4 seeds.

M. longifolia is valued as an avenue or compound tree and cultivated for its handsome foliage and sweet scented flowers. The flowers appear in the hot weather and fruits ripen during the rainy season [Haines, II, 54; Fl. Madras, 75; Firminger, 610; Benthall, 32; Santapau, *Rec. bot. Surv. India*, 1953, **16** (1), 18].

Fresh flowers of the tree are used like those of *Mesua ferrea* for worship in temples and for personal adornment. Dried flowers keep their fragrance for a long time; a perfume, resembling that of violets, can be extracted from them. Flower buds contain a colouring matter which dyes silk red. The buds possess mild stimulant, carminative and astringent properties and are used in dyspepsia and haemorrhoids [Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6** (4), suppl., 50; Krishnamurti Naidu, 142].

The fruit is edible: it contains a soft juicy pulp with the flavour of rose water. The wood (wt., 55–60 lb./cu. ft.) is red, hard, close and even-grained; it is occasionally used for building purposes (Benthall, 32; Talbot, I, 97; Cameron, 15).

M. siamensis T. Anders. syn. *Ochrocarpus siamensis* T. Anders. is a middle-sized evergreen tree, native

of Burma, S. Viet-Nam and Thailand, reported to occur in the Lushai hills. It is similar to *M. longifolia* and bears white fragrant flowers and ovoid fruits, *c.* 3 cm. long. An essential oil with the aroma of violets has been isolated from the flowers. The pollen is said to be used by the Siamese as a cosmetic. Seeds contain 7% of an acrid resin. The wood of this species is similar to that of other species already referred to; it is suitable for cabinet work [Fl. Assam, I, 111; Krishna & Badhwar, loc. cit.; Wehmer, II, 784; Burkill, II, 1570; Gamble, 56].

Mammey Apple — *see* **Mammea**

Mana Grass — *see* **Cymbopogon**

Manatees — *see* **Halicores**

MANDRAGORA Linn. (*Solanaceae*)

D.E.P., V, 143; Fl. Br. Ind., IV, 241.

A small genus of perennial herbs native of the Mediterranean and Himalayan regions. One species occurs in India.

M. caulescens C. B. Clarke is a herb, 30–36 cm. or more in height, with stout roots, obovate leaves and campanulate, greenish purple flowers, found in Sikkim at altitudes of 3,600–3,900 m. The plant contains an alkaloid mandragorine ($C_{15}H_{19}O_2N$) and is suspected to be poisonous; mandragorine yields on hydrolysis tropic acid and a base resembling tropine [Smith, *Rec. bot. Surv. India*, 1913, **4** (7), 399; Chopra, 1958, 547; Henry, 83].

M. autumnalis Spreng. syn. *M. microcarpa* Bertol. and *M. officinarum* Linn. (Mandrake; Hindi—*Luckmuna, lufah*; Beng.—*Yebruj*; Tam.—*Kaatjuti*) are herbs found in the Mediterranean region. The roots of these plants are reported to possess properties similar to those of belladona and are sold in the bazaars of North India. The drug is considered sedative, hypnotic, mydriatic and anaesthetic; in Patna, it is used as a narcotic. The roots are reported to contain the alkaloids, hyoscyamine, hyoscine, ψ-hyoscyamine (probably identical with *nor*hyoscyamine), cuscohygrine and mandragorine (Martindale, I, 1378; Hocking, 134; Henry, 83; van Haga, *Nature, Lond.*, 1954, **174,** 833).

Mandrake — *see* **Mandragora**

MANGANESE ORES

Manganese occurs chiefly as Pyrolusite, Braunite, Psilomelane and Manganite. The first three are by far the most important ores of manganese and account for over 95% of the world's output. Manganese ores of lesser importance include Hollandite, Sitaparite, Jacobsite, Hausmannite, Rhodonite and Spessartite.

Pyrolusite (MnO_2; sp. gr., 4.73–4.86; H., 2.0–2.5) is the most common ore of manganese. It occurs in fine-grained, sub-crystalline, friable form and is iron-black or dark steel-grey in colour. The coarse crystalline variety is called Polianite. Pyrolusite is a mineral of secondary origin.

Psilomelane (sp. gr., 3.3–4.7; H., 5–7) also an oxide of manganese containing varying amounts of barium, potassium and sodium oxides and water, usually occurs, along with pyrolusite, in colloidal form; pseudocrystalline and crypto-crystalline forms are also known. It is iron-black or steel-grey in colour. Earthy mixtures of psilomelane and pyrolusite with impurities, like iron oxide and water, are known as Wad.

Braunite ($3Mn_2O_3 . MnSiO_3$; sp. gr., 4.75–4.82; H., 6–6.5) is a brownish black mineral occurring in fine or coarse crystalline form. Next to psilomelane, it is the most abundant manganese ore in India.

Manganite [$MnO(OH)$ or $Mn_2O_3 . H_2O$; sp. gr., 4.2–4.4; H., 4] is dark grey to black in colour with reddish brown streaks and sub-metallic lustre. It occurs as orthorhombic crystals frequently associated with barytes and calcite.

Manganese ores occur as bedded sedimentary deposits, varying in age from the Archaean ores of India and South Africa to the extensive tertiary ores of the Soviet Union. The Soviet Union is the largest producer of manganese ore in the world, accounting for nearly 50% of the total output; India is the second largest producer. Other important producing countries are Ghana, South Africa and Brazil. Together, these countries account for nearly 80% of the world's annual output. Table 1 gives the world production of manganese ores during 1955–59.

The principal deposits found in India may be classified, according to their mode of occurrence and origin, into four main groups: (*i*) primary bedded or reef deposits of the gondite type enclosed within pre-Cambrian metasedimentary rock of Sausar series and allied rocks in Balaghat, Bhandara, Nagpur, Chhindwara, Jhabua, Panch Mahals and Banswara districts of Madhya Pradesh, Maharastra and Rajasthan; (*ii*) secondary supergene alteration products from primary bedded manganiferous rocks of the Kodurite type, enclosed within Khondalite series in

TABLE 1—WORLD PRODUCTION OF MANGANESE ORES*
(Qty in thousand metric tons)

	1955	1956	1957	1958	1959†
U.S.S.R.	4,743	4,938	5,148	5,366	n.a.
India	1,609	1,764	1,681	1,276	1,187
South Africa	589	697	715	847	945
Ghana††	548	646	651	521	542
Congo	462	329	367	331	386
Morocco (Southern)	411	422	492	410	471
Rumania	390	235	265	200	n.a.
China†	280	530	540	540	n.a.
Brazil	212	311	918	695	625
Estimated world production (including estimates for countries not listed)	10,874	11,760	12,815	11,865	12,000

* *Indian Minerals Yearbook*, Indian Bureau of Mines, 1959, 231.
† Estimated; n.a.—not available; †† exports.

Visakhapatnam, Srikakulam, Ganjam, Koraput, Kalahandi and Patna regions of Andhra and Orissa; (*iii*) secondary supergene enrichments and replacement deposits in shales, phyllites and schists, associated with banded iron formations and other rocks in Singhbhum–Bonai–Keonjhar areas of Bihar and Orissa, and in Shimoga, Chitaldrug, Tumkur, Bellary and North Kanara districts of Mysore: and (*iv*) lateritoid deposits and residual weathering products derived from and associated with primary bedded and supergene deposits. The gonditic deposits of Madhya Pradesh and Maharashtra are by far the most important accounting for more than 50% of the total Indian production: these are followed in order of importance by supergene oxide deposits of Orissa, Mysore and Andhra Pradesh. The gondites form conformable beds within the enclosing rocks having considerable lateral as well as downward extension, while the kodurite deposits form conformable lenses, layers and irregular segregations of smaller size within highly weathered host rocks, the oxidation and enrichment being localized in areas of drag-folding. The supergene enrichments and replacements and lateritoid cappings form tabular concordant lenses and discordant reefs of varying size and shape (Roy, in *Symposium on Iron and Manganese Ores of India*, Geological, Mining and Metallurgical Society of India, Calcutta, 1960).

The gondite deposits have been formed from manganese-bearing sediments as a result of regional movements and profound metamorphism. The kodurite deposits have possibly resulted from the invasion of manganiferous sediments into granitic rocks. The laterite type of deposits are due to metasomatic replacement of Dharwar rocks by underground water containing manganese solutions. The ores in the first two groups of deposits have been, to some extent, altered by water and atmospheric agencies and reconstituted at the surface and extend to some depth. The lateritic ores are confined to the surface, and extend to some depth only under the influence of surface water (Dey, *Rec. geol. Surv. India*, 1954, **80**, 474; Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 209).

The total reserves of ores of all grades in India have been estimated at 100 million tons, of which about 85 million tons are in Madhya Pradesh and Maharashtra.

Distribution in India

Andhra Pradesh—Deposits of manganese ore occur in the Srikakulam dist. along four main belts: (*i*) a southern belt comprising the quarries of Kodur (18°16′30″:80°33′), Devada and Chinna Bantupalle, (*ii*) a south-central belt covering the quarries of Garbham (18°22′30″:83°27′30″), Vedullavalasa, Avagudem, Chipurupalle (18°19′:83°34′) and Perapi, (*iii*) a north-central belt including the quarries of Aitemvalasa, Gadabavalasa, Batuva, Karlam and Nimmalavalasa, and (*iv*) a northern belt consisting of the quarries of Gotnandi, Garuja and Joda. The deposits in Chipurupalle taluk are being exploited at Kodur, Garividi, Garbham, Perapi, Avagudem and Aitemvalasa; the Garbham deposit is probably the largest in the country. In Salur taluk, manganese occurs near Timuruvalli, Andhraporam, Pachipenta, Ramabhadrapuram, Peddapadam, Ponam, Medangi, Mamidipalle and Kottavalasa; the deposits usually carry low grade ore containing c. 36% Mn (Rao, in *Symposium on Iron and Manganese Ores of India*, 1960; Hussain, ibid.).

In Visakhapatnam dist., manganese ore is found at Gotivada (17°33′:82°44′) near Narsapatam and in Srungavarapukota taluk. Occurrences have also been reported from Kurnool and Nellore districts [Laxminarayanarao, *J. Min. Metals & Fuels*, 1960, **8**(2), 20; Rao, loc. cit.; Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 216].

Bihar—Deposits of manganese ore occur in Singhbhum dist. in 3 regions; one extending from Gua

(22°13′:85°23′) to Limtu and thence to Keonjhar in Orissa, another between Jamda and Noamundi (22°09′:85°29′) and the third, between Chaibasa and Jamda. The ore has been quarried in some areas between Noamundi and Gua, Kamarhatu, Nimdih and an area 6 miles south of Chaibasa. Deposits have been located in Leda Buru (22°28′:85°23′) and Lanji (22°49′:85°35′). Occurrences have also been reported south of Chaibasa close to Madkamhatu, Gitilpi, Kelandeh, Tutugutu, Surajbasa and Bistampur. The deposits consist of psilomelane and pyrolusite, usually associated with phyllitic and schistose rocks; ore containing 30–44% Mn is generally obtained by hand picking [Dunn, *Mem. geol. Surv. India*, 1941, **78**, 174; *Rec. geol. Surv. India*, 1954, **86**(1), 113].

In Manbhum dist., low grade ore occurs near Paharpur. A few occurrences have also been noted in Monghyr dist.

Gujarat—In Panch Mahals and Baroda districts, psilomelane, pyrolusite and braunite occur as tabular beds or reefs near Shivrajpur (22°25′30″:73°40′), Bamankua (22°26′30″:73°39′), Talaori 22°28′:73°41′) and Pani (22°23′:73°51′); the ores are associated with manganiferous phyllites, calcareous phyllites and limestones. The ore belt at Shivrajpur consists of three parallel reefs, extending east–west for *c.* 1 mile from Bapotia (22°24′:73°38′) and taking a northerly bend towards east of Shivrajpur for a distance of 2 miles where it peters out. The reserves of the ore (Mn, 46%) have been estimated at 1.7 million tons. Manganese occurs in Bamankua area in a 40 ft. thick ore zone; the reserves are estimated at 0.3 million tons within a depth of 300 ft. The ore zone at Pani extends for nearly 2 miles with a sharp S-bend near Pani mines railway station and carries within 300 ft. depth a reserve of about 0.5 million tons. At Shivrajpur, Bamankua and Pani the ore reefs have been proved to a depth of 500 ft. and possibly they extend further down. Manganese also occurs at Gandhra, Vav, Bhabar, Anas and Ambala as supergene oxide deposits and at Jothwad, in association with gonditic rocks (Mahajan, in *Symposium on Iron and Manganese Ores of India*, 1960).

Smaller deposits of manganese ores have been reported also from Sabarkantha and Banaskantha districts.

Madhya Pradesh—In Chhindwara dist., deposits of first and second grade manganese ore occur in Gowari-Wadhona, Kachhi-Dhana, Sitapur and Lodikhera areas. Ore bands, 5–10 ft. thick, are exposed along strikes which extend from a few hundred to 2,000 ft. in length.

In Balaghat dist., extensive deposits of manganese ore occur in a number of localities. In the eastern part of the dist., bedded ore occurs near the base of a thick series of phyllites and schists of the Chilpi Ghat series. The bed runs E.NE–W.SE over a distance of 13 miles from Ukwa to Uskal river. The ore consists mainly of fine-grained braunite and psilomelane; some pyrolusite, hausmannite, etc., are also found. The ore in the Ukwa area averages to 50% Mn, 4% SiO_2 and 0.03% P. Beyond Uskal river, towards the west, the ore band reappears 8 miles further west on the Bharweli ridge, 2½ miles north-east of Balaghat town; the deposit contains on an average, 50% Mn. Less important deposits occur east of Ukwa and west of Baihar near Chini.

The deposits in the eastern region have been worked by open-cast methods up to a depth of 70 ft. in Langur and Jagantola mines; in Bharweli and Ukwa mines the ore is extracted by underground working, the deepest working being *c.* 600 ft. below the outcrop; the occurrence of ore has been proved up to a depth of 800 ft. in Bharweli. The reserves in the region have been estimated at *c.* 9.4 million tons (Shukla & Anandalwar, in *Symposium on Iron and Manganese Ores of India*, 1960).

Manganese mines of the north-central region of Balaghat dist. are located in Waraseoni tehsil in a belt extending for over 4 miles from Ramrama to Netra and beyond. Of the 13 working mines in the belt, those of Ramrama, Shodhan Hurki, Gulla Hurki and Netra are important. The reserves of all grades of the ore in the area have been estimated at 2.75 million tons (Subramanyam, in *Symposium on Iron and Manganese Ores of India*, 1960).

In the south-west region of Balaghat dist., about 50 deposits have been located within an area of 290 sq. miles. The principal deposits are found at Tirodi, Sukri, Sitapathor, Jamrapania, Pawnia and Kosamba. The assessed reserves in Tirodi and Sukri deposits are 1.5 million tons; the inferred reserves are 15 million tons. Stray occurrences of manganese ore have been reported between Katanghiri and Budbuda in the area south of Ramrama and between Katanjheri and Mohgaon (Vemban & Nagarajaiah, in *Symposium on Iron and Manganese Ores of India*, 1960).

The deposits of Balaghat dist. account for 27–30% of the total Indian production (Narayanan & Subrahmanyan, 2).

In Nimar (Khargone) dist., manganese ore deposits occur near Burwaha town. The deposits between Nandnia (22°15′: 76°01′) and Agarwara (22°17′: 76°59′) are now being worked. The manganese content of the ore varies between 20.1 and 54.7%. A number of occurrences have also been recorded in the adjoining Dhar Forest area (Roy Chowdhury, *Bull. geol. Surv. India, Ser. A.*, No. 10, 1955, 57).

In Jhabua dist., manganese ores occur in association with quartzite and are usually of low grade. The chief deposits are in Thandla tehsil over an area 6 miles long and 4 miles wide; the more important occurrences are Kajilidongri (22°57′: 74°28′30″), Rampura (22°57′: 74°25′), Mandli (22°57′30″: 74°24′), Tumdia (22°57′45″: 74°24′), Bandiwar (22°28′: 74°27′), Kelkua (22°59′: 74°29′), Amliamal 23°0′: 74°25′), Jaikot (23°01′: 74°25′) and Talai (23°01′30″: 74°25′). The Kajilidongri deposit (Mn, 40.4–44.5%) is the most promising; the reserves within a depth of 50 ft. are estimated at 837,000 tons. Manganese ore is also mined from Tumdia, Bandiwar and Amliamal areas. The occurrences in other localities, except Mandli, are of poor grade. In the northern part of Jhabua dist., ore deposits have been reported at Udwara (22°23′: 74°27′), Arandifalia (22°30′: 74°37′), Ringol (22°37′: 74°17′), Sejwada (22°37′: 74°20′), Dotad (22°42′: 74°28′), Baoli (22°48′: 74°29′), Pitol (22°47′: 74°28′) and Nagankheri (Roy Chowdhury, loc. cit.; Venkatesh *et al., A Preliminary Rep. on the Geology and Manganese Ore deposits of the northern part of the Jhabua dist., Madhya Pradesh*, Geol. Surv. India, 1958).

Manganese ore has also been found in Jabalpur, Bilaspur, Sidhi and Seoni districts.

Maharashtra– In Nagpur dist., manganese ores of good quality occur as lenticular masses at Kodegaon, Gumgoan and Ramdongri. The deposits have been worked up to a depth of 100–200 ft. Manganese is also found at Kandri, Mansar, Lohdongri and Beldongri. The ore (Mn, 48–54%) is usually won by underground mining in Kandri Mansar area which carries reserves of about 1.9 million tons.

Manganese occurs in several localities in the area comprising Katchkuri, Junewani, Mendvi Bir, and Bhinadeo: and in Salai Ghoti, Chorbaoli Muknapur, Manegaon Gurguldoh and Mandri–Bhandarbodi areas. Occurrences have also been reported between Satak and Waregaon, a distance of *c.* 17 miles. The deposits at Nalgondi, Sitagondi, Pendri, Warpani, Hatikadan, Bhiwagarh, Ambajhari and Dhaulapur contain ores analysing to 36 40% Mn. Highly siliceous ores are reported to occur at Kaotha, Khapa, Richara, Maharkund, Padri, Pali and Parseoni (Hussain, in *Symposium on Iron and Manganese Ores of India*, 1960; Rao & Singh, ibid.).

In Bhandra dist., extensive deposits are found in Dongri Buzurg, Kunkurma, Chikla and Sitasaongi areas. The Dongri Buzurg deposit, located on a small hill, is worked for secondary oxide and peroxide ores (Mn, 50%); the proved reserves in the area are estimated at 4.5 million tons. The Chikla area is rich in manganese ores and the reserves of the ore (Mn, 40–50%) in the more important deposits amount to 4.9 million tons. Less important are the occurrences at Karli, Lamankurki, Alesur and Phutara. Sizeable ore deposits also occur at Kurmura, Asolpani, Nawegaon and a few other places (Hussain, loc. cit.; Narayanaswami & Venkatesh, in *Symposium on Iron and Manganese Ores of India*, 1960; *East. Met. Rev.*, 1955–56, **8**, 432).

In Ratnagiri dist., manganese ore occurs as veins in laterite at Rairi Point (15°45′: 73°43′); minor deposits are found in the former Sawantwadi state at Fondiye, Fakirpata and a few other places (Roy, 1951, 99).

In Satara dist., low grade ores occur in the vicinity of Savitri pass, Mahabaleshwar, Lingmala and several other places [Roy, *Rec. geol. Surv. India*, 1954, **85**(1), 74].

In Goa, manganese ore, often associated with ochre and iron, occurs in Sanguem, Quepem and Bicholim districts. The more important deposits (Mn, 32.6 46.2%) are found in the Villiena area in Sanguem dist.; the ore is mined also at Maulinguem, Zuma, Kumari, Curdi, Naturlim, Vichondrem, Rivona, Curpem, Colomba, Costi, Jacqui and Tudou (Dhepe, *J. Univ. Poona*, 1953, No. 4, 27).

Mysore–In Bellary dist., shallow deposits of lateritoid ore occur in Sandur taluk as narrow lenses over a distance of 20 miles, from Ramandrug in north-west to Kammadhevuru in south-east. The Ramandrug deposits have been exploited to exhaustion; only low grade ores are left in old workings. Mining is carried out in Kammadhevuru–Kanavehalli region, where the ores extend down to 30 ft. depth: the manganese content of the ore averages to 32–35%, though local concentrations of high grade material (Mn, 50–52%) are not uncommon. The reserves in the region have been estimated at 0.8 million tons. Other deposits of importance are located at Kallahally, Ankammanhal, Yarenhalli, Deogiri, Aligilavada, Tonashigri and Tumraguddi reserved forests, and Teligi hill. The total reserves in

the district have been estimated at 4 million tons, of which 3 million tons may be of low grade (Mn, 39% and below) [Krishnamurty, in *Symposium on Iron and Manganese Ores of India*, 1960; *Annu. Rep. Mysore geol. Dep.*, 1955–56, 42; Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 216; Pradhan & Dewan, *Indian Min. J.*, 1957, **5**(spec. issue), 67].

In Shimoga, Chitaldrug and Tumkur districts, the ore deposits are distributed in eight main areas: Shankargudda, Kumsi, Shikarpur, Channagiri and Shiddarhalli group in Shimoga dist.; and Chiknayakkanhalli, Karekarichi and Kondli group in Tumkur and Chitaldrug districts. The ore occurs as enrichments in phyllites, schists and quartzites and forms conformable lenses, layers and irregular segregations which extend to a maximum length of 1,000 ft. The ore analyses to 35–45% Mn and is low in phosphorus. The localities in which sizeable deposits occur are: Chitaldrug dist.—Nellikatte, Bheemasamudra, Sadarhalli, Mahadevapura, Garga, Dodkittadhalli, Hirekandavadi, Kudurekanivekaval, and Kenkere; Shimoga dist.—Kumsi, Joldhal, Hosur, Tharlaghatta and Hanigeri; and Tumkur dist.—Honnebagi, Bullenahalli, Gollarhalli, Janehar, Yarekatte, Kandikere, Kondli, Hombalghatta, Hatyal, Doregudda, Hoshalli, Shivasandra, Mavinhalli, Sondenhalli and Harenhalli. The reserves in these areas are estimated at 1–2 million tons. Shimoga ore is used by the *Mysore Iron & Steel Works*, Bhadravati for the manufacture of ferro-manganese [Karunakaran, in *Symposium on Iron and Manganese Ores of India*, 1960; *Rec. Mysore geol. Dep.*, 1956, **52**(1), 61; *Annu. Rep. Mysore geol. Dep.*, 1955–56, 42].

In North Kanara and Belgaum districts, low grade manganese ore occurs in 5 belts covering an area of 230 sq. miles in Supapeta and Khanapur taluks; the major deposits are in the Supapeta region. The ore bodies are confined to phyllites and quartzites and lateritic cappings associated with Dharwar rocks. Of

Geol. Surv. India. Photo: W. D. West

FIG. 88. MANGANESE ORE MINE, GUMGAON

the 5 belts, one passes through Kundal-Zalwali and another through Terali and Diggi: the major portions of the two belts appear to lie in Goa territory. The third belt emerges from near Amboli village and runs in the north-west direction to Ambeli Pote, then west-north-west to Sulavali and finally to Goa. The fourth belt emerges in the Gund range in the southern extremity of Supapeta, disappears for some distance, and reappears in the form of sharp exposures up to Vilva and then runs north-west to the north of Castle Rock; subsidiary off-shoots of this belt appear in some localities. The last belt outcrops in the Nagargalli and Kundedgaon hills, runs for 2–3 miles in the north-west direction and appears in Mendil, Degaon, Gowli, Jamgaon and Bhimgad areas. The ores are usually rich in iron and contain also silica and phosphorus in low concentration. The total reserves in the 5 belts have been estimated at 10 million tons, of which nearly 50% is of exploitable grade (Sahasrabudhe, in *Symposium on Iron and Manganese Ores of India*, 1960; Kapadia *et al.*, *Rep. Beneficiation of Low Grade Ores*, Govt. of India, 1957, 18).

Minor deposits have been reported from Bijapur, Dharwar and Chikmagalur districts.

Orissa—Deposits of manganese ore, about 1,000 ft. long and up to 20 ft. thick, occur mainly in the Jamda-Koira valley in Keonjhar and Sundargarh districts of Orissa, extending to Singhbhum dist. in Bihar. They generally contain lateritic and cavernous ores: the principal manganese minerals present are psilomelane, cryptomelane and pyrolusite. The grade of ore varies widely even within individual deposits and only 30% of the deposits contain more than 40% Mn: a few contain dioxide ore (97% MnO_2) of chemical and battery grade. The more important occurrences are: Keonjhar dist.—Nalda, Jamda, Belkundi, Barabil, Bhadrasai (23°04′:85°24′), Bonoikora, Kalimati, Dhubua (21°51′:85°24′), Jampani (21°52′:85°23′30″), Joda, Roida (22°01′:85°23′), Bamebari (21°54′:85°25′), Siljora and Thakurani (23°03′30″:85°27′15″); Sundargarh dist. (Bonai sub-division)—Malda (21°56′:85°20′), Koira Range (21°54′:85°15′), Orahuri, Kusumdih, Patmunda (21°52′:85°19′), and Bhutura (21°47′:85°09′). The probable reserves in the Keonjhar-Bonai area and adjoining parts of Singhbhum dist. are 20 million tons. In Gangpur sub-division of Sundargarh dist., fairly rich deposits are found in certain areas: those near Dandjamira and Nakti (22°7′:84°13′) and in Ghoriajor-Manomunda area are being exploited (Rao & Murty, in *Symposium on Iron and Manganese Ores of India*, 1960; Nandy, *Tisco*, 1955, **2**, 80; Spencer, *Trans. min. geol. Inst. India*, 1948, **44**, 61; Khedker, 152; Dey, *Rec. geol. Surv. India*, 1954, **80**, 479; Krishnan, *Mem. geol. Surv. India*, 1937, **71**, 130).

In Koraput and Kalahandi districts, manganese ore deposits occur in deeply weathered rocks of the Khondalite series; they are composed chiefly of pyrolusite, psilomelane and wad with subordinate braunite. The ore is ferruginous and of low grade. Deposits are found at Kutingi (19°05′:83°10′), Nishkhal (19°13′:83°13′), Kashipur, Podakona, Liligumma, Pullabadi and Taldoshi. In the Kutingi area, patchy deposits occur along a narrow belt nearly 1½ miles long; of the total estimated reserves of 0.4 million tons in the area, at least half is of good quality, averaging *c.* 50% Mn. The deposits near Nishkhal are likely to yield at least 0.25 million tons of ore and the reserves in Kashipur area are estimated at 0.1 million tons. Proved reserves in Koraput and Kalahandi areas are estimated at 1 million tons [Gokulam, in *Symposium on Iron and Manganese Ores of India*, 1960; Economic Geology of Orissa, 91; Murty, *Rec. geol. Surv. India*, 1954, **85**(1), 75; Coggin Brown & Dey, 213; Engineer, *Indian Constr. News*, 1959, **8**(8), 107].

In the former Patna state, ferruginous manganese ore is found in several localities within a zone *c.* 15 miles long. The more important occurrences are Bhaludungri (20°46′:83°21′), Gadshankar (29°47′:83°22′), Satparliadungri (20°50′:83°20′), Kapilbahal (20°46′:83°19′), Kumiapali (20°46′:83°16′) and Kaniamanga (20°48′:83°14′). The reserves up to 50 ft. depth are estimated at 650,000 tons (Krishnaswami, in *Symposium on Iron and Manganese Ores of India*, 1960).

In Cuttack and Ganjam districts and in the former Rairakhol and Bamra states, several occurrences of manganese have been reported. Low grade ferruginous ores (Mn, av. 25.43%) have been recorded near Kandhal (21°03′:84°10′) in Rairakhol state, the reserves being estimated at 60,000 tons up to a depth of 50 ft.

Rajasthan—In Banswara dist., manganese ores occur in Sivania (23°19′30″:74°16′), Kalakhunta, Sagwa, Ghatia, Itala, Tambesara (23°15′:74°21′), Khedia, Pukhera, Loharia and a few other areas. The reserves at Tambesara are estimated at 0.5 million tons. The ores of Banswara dist. are rather high in silica and contain 31.70–57.00% Mn. The reserves in

the district have been assessed at 2.1 million tons (Kapadia *et al.*, *Rep. Beneficiation of Low Grade Ores*, Govt. of India, 1957, 25).

In Udaipur dist., low grade manganese ores occur in association with quartzites near Lakawas (24°33′: 73°51′), Kanpur (24°34′: 73°49′), Debari (24°36′: 73°50′), Panda (24°32′: 73°47′), Nathdwara (24°56′: 73°51′) and Titri. A zone of manganiferous phyllites and quartzites, c. 1 mile long and 33-100 yd. broad, has been reported west of Lakawas. A deposit in north of Kanpur is being worked. Debari and Nathdwara areas do not appear promising; further prospecting has been recommended in the area near Panda, where the manganiferous zone appears to be at least 100 ft. wide (Roy, *Mem. geol. Surv. India*, 1959, **86**, 233; Sethi, 39).

In Jodhpur division, occurrences of low grade manganese ore have been recorded near Bar (26°05′: 74°09′) and Haripur (26°01′: 74°05′). Occurrences have also been recorded in Ajmer, Alwar, Bharatpur, Bundi, Dholpur and Jaipur regions.

West Bengal – In Midnapur dist., deposits containing pyrolusite, cryptomelane and manganite, in association with iron ores, occur near Thakuranipahari in an area of 4 sq. miles in extent: the ore contains c. 45% Mn (Chakraborty, in *Symposium on Iron and Manganese Ores of India*, 1960).

Mining

Manganese ore is raised mainly by open cast methods. The deposits are quarried usually by manual labour; only a few mines employ power shovels, euclids and churn drills. Two types of deposits are mined, those containing float ore (formed from ore lumps dislodged from the parent mass by a process of disintegration) and bedded ores. Mining of float ore involves digging, hand screening and hand jigging sized material to remove light gangue. The ore is not crushed and jig concentrates are not always of the required quality. Bedded deposits are exploded by blasting: mined ore is crushed to suitable size and the coarse fraction handpicked. Only those deposits, which yield a marketable grade of concentrate, are being exploited at present. Of the 536 manganese mines at present in operation, underground mining is resorted to only at Bharweli, Ikwa and Gowari-Wadhona in Madhya Pradesh, Mansar and Chikla in Maharashtra, and Shivrajpur in Gujarat [Narayanan, *Indian Min. J.*, 1957, **5** (spec. issue), 24; *Indian Minerals Yearbook*, Indian Bureau of Mines, 1959, 218].

Beneficiation and Grading

At the present rate of mining, the known deposits of high grade manganese ore in India are estimated to last only 30 years. The reserves of low grade ores are extensive; and suitable methods are being increasingly adopted for beneficiating them in order to conserve the high grade material.

Clay and fine dust adhering to ore lumps, are removed by washing in trough washers, log washers, wash trommels, etc. Mechanical washers are in use at Tirodi and Bara Jamda mine; tumblers are employed by some mines in North Kanara (Mysore) for removing laterite coating.

Hand sorting is widely adopted for improving the grade of ore. Hand jigging is employed in some areas for upgrading float ore and rejects. Joplin jigs are mostly used for this purpose; mechanically operated jigs are used at Shivrajpur (Gujarat) (Narayanan & Subrahmanyan, 28; Kapadia *et al.*, *Rep. Beneficiation of Low Grade Ores*, Govt. of India, 1957, 34; Shukla *et al.*, *Rep. Mineral Beneficiation Comm.*, Govt. of India, 1959, 29).

A heavy media separation plant is in operation at Dongri Buzurg, near Nagpur, for beneficiating low grade ores. Another plant will be shortly set up at Garividi in Srikakulam dist. (Andhra Pradesh). The ore is crushed in primary jaw crushers, screened and fed into a Wemco drum containing a suspension of ferrosilicon and water (density, 3.1 g./ml.). The sink

Geol. Surv. India. Photo: G. V. Rao

FIG. 89. MANGANESE ORE DRESSING AFTER HAND SORTING

and float products are passed over separate screens to recover the ferrosilicon medium. The sink consists of good grade ore along with waste rock and small quantities of low grade ore; waste rock is removed by hand picking. Low grade lumps are conveyed to a secondary crusher to liberate the gangue and fed along with fresh feed to the drum. The float is rejected. The beneficiated material contains 50–51% Mn [Narayanan & Subrahmanyan, 26–27; Kapadia *et al.*, loc. cit.; Sinha, *Indian Min. J.*, 1958, **6**(6), 21].

Manganese minerals commonly found in India are feebly magnetic and are amenable to separation from quartz, amphiboles, pyroxenes, barite, calcite, apatite, etc. by employing high intensity magnetic fields (Narayanan & Subrahmanyan, 29).

Various hydrometallurgical processes for beneficiating low grade ores are known. The manganese in the ore is brought into solution by treatment with sulphur dioxide, ferrous sulphate, acids or caustic soda and soluble impurities separated from the leach liquor by selective precipitation by the addition of suitable chemical reagents. The filtered manganese solution is concentrated and decomposed to give the oxide. A preliminary reduction roast facilitates solubilization of manganese. A process involving solubilization of manganese by passing sulphur dioxide under pressure, followed by high temperature autoclaving and sintering, has been developed in U.S.A. for beneficiating poor grade material containing as low as 20% Mn. Another process developed in Canada, is suitable for treating low-grade pyrolusite ores containing 5% Mn or even less; manganese sulphate ($MnSO_4.H_2O$) is obtained by thermal precipitation from the leach liquors. The National Metallurgical Laboratory, Jamshedpur, has developed a process for obtaining manganese dioxide of high purity from low grade ores; the ore is reduced and leached with commercial sulphuric acid; and manganese dioxide is obtained by electrolysis [Narayanan & Subrahmanyan, 22; Sully, 88; Kar, *East. Met. Rev.*, 1955-56, **8**, 494, 518; *J. sci. industr. Res.*, 1954, **13A**, 395; *Chem. Engng News*, 1957, **35**(29), 70; *Res. & Ind.*, 1959, **4**, 276].

Pyrometallurgical processes have been developed for the recovery of manganese from low grade ores and slags. They are particularly useful for producing enriched manganese slag low in phosphorus and iron, and suitable for the production of standard ferromanganese. A thermal process for the treatment of low grade ferruginous ores has been evolved at the National Metallurgical Laboratory, Jamshedpur. Pilot plant trials with Sandur ores have yielded encouraging results [Nijhawan, *Indian Min. J.*, 1957, **5** (spec. issue), 140; Narayanan & Subrahmanyan, 22; Lalkaka, *Trans. Indian Inst. Metals*, 1959, **12**, 235; *Annu. Rep. Nat. Metallurgical Lab.*, Jamshedpur, 1960–61, 110, 111].

Grading—Manganese ores exhibit wide variability in their manganese and iron contents. The bulk of the mined ores are used for metallurgical purposes. Ores, containing more than 35% Mn are suitable for the manufacture of ferromanganese alloys (Mn, 72–82%). Ferruginous ores contain 10–35% Mn and are used in the manufacture of spiegeleisen (Mn, 18–22%). Manganiferous iron ores, containing 5–10% manganese, are employed for the production of pig iron (Sully, 4).

The ores are classed on the basis of manganese content into 3 grades: the first contains 48% or more of Mn and the second grade, 45–48% Mn; ores containing 30–45% Mn belong to the third grade; and those analysing to less than 30% Mn and low in iron are not marketable. The character of the ore determines the purpose for which it is to be used. Ore required for chemical industries should contain a high percentage of manganese dioxide: it may contain appreciable quantities of phosphorus and silica, but should be low in iron and lime. Ores high in lime and low in oxygen, phosphorus, silica and alumina are used for metallurgical purposes and classed as metallurgical or furnace ore. Ore deposits which are now exploited in Maharashtra and Madhya Pradesh yield first grade ore; second and third grade ores are largely mined in Singhbhum (Bihar), Keonjhar (Orissa) and Mysore. Analyses of some Indian ores are given in Table 2.

Specifications and grades for ores used in industries are given in Table 3. The Mineral Beneficiation Committee of the Government of India has specified that manganese ore used in the manufacture of standard grade ferromanganese should contain: Mn, $\nless 48$; Fe, $\ngtr 7$; $SiO_2 + Al_2O_3$, $\ngtr 12$; P, $\ngtr 0.15$; Zn, $\ngtr 1\%$; copper, barium and lead, in traces; and manganese: iron ratio, 7 and above [Engineer, *Indian Constr. News*, 1959, **8**(8), 106; Shukla *et al.*, *Rep. Mineral Beneficiation Comm.*, Govt. of India, 1959, 28].

The largest producer of manganese ore in India, the *Central Provinces Manganese Ore Company*, markets two grades of metallurgical ore, Oriental Mixture and Bawantheri Mixture. The two grades are mixed before despatch to consumers. The ana-

TABLE 2—ANALYSES (%) OF INDIAN MANGANESE ORES*

	Mn	Fe	SiO_2	P	MnO_2
Madhya Pradesh					
Balaghat mine ore	51.0	7.0	6.5	0.10	55.0
Boulder ore	48.5	8.0	5.5	0.06	45.0
Maharashtra					
Bhandara mine ore	50.5	7.5	8.0	0.16	28.0
Boulder ore	49.5	7.5	7.0	0.08	34.0
Dongri, run of mine ore	51.25	6.5	3.5	0.275	75.0
do. low ferruginous peroxide ore	59.0	1.0 (max.)	1.0 (max.)	0.29	90.0
do. standard peroxide ore	58.5	2.75 (max.)	2.0 (max.)	0.32	88.5
Gujarat					
Shivrajpur, first grade	48–50	4–5	6–8	0.23–0.26	..
do. second grade	46–47	5–7	9–11	0.24–0.28	..
do. third grade	43–44	6–8	12–14	0.24–0.27	..
Orissa					
Keonjhar, first grade	49.0	8.56	4.40	0.135	
do. second grade	45.8	8.18	5.25	0.165	..
do. third grade	40.0	13.80	5.70	0.047	..
Manganese dioxide ore, first grade	..	0.16	0.40	..	91.96
do. second grade	..	0.91	0.95	..	88.0
Mysore					
Sandur, low-grade ore	40.2	16.40	1.0–2.0	0.02	56.5

* Coggin Brown & Dey, 214.

lytical values of the two mixture are as follows: *Oriental mixture*—Mn, 51.0; P, 0.106; SiO_2, 7.0; and Fe, 7.0%; *Bawantheri mixture*—Mn, 47–48; P, 0.15; SiO_2, 7.5; and Fe, 9%. The former is suitable for direct use in ferromanganese manufacture; the phosphorus content is guaranteed to be less than 0.12% (Dey, *Rec. geol. Surv. India*, 1954, **80**, 465).

Uses

Manganese ore is largely used for metallurgical purposes, particularly in the iron and steel industry. Approximately 1.3 tons of ore are required for the production of 100 tons of pig iron.

Manganese is usually added in the form of ferro-alloy to produce steel and the most important alloy employed for this purpose is standard ferromanganese (Mn, 78–82%); spiegeleisen (Mn, 18–22%) and manganiferous pig iron (Mn, 4–10%) are used in much smaller quantities. Manganese acts as deoxidizer and desulphurizer and ensures the production of relatively clean ingots free from blow holes. Approximately 2 tons of high grade manganese ore are required to produce 1 ton of standard ferromanganese. Special tough steels, resistant to abrasion and distortion, contain 11–15% Mn. Manganese is also used in the production of non-ferrous alloys, like manganese bronze, nichrome, monel metal, german silver, manganin, duralumin, invar, etc. [Sully, 7; Engineer, *Indian Constr. News*, 1959, **8**(8), 106].

High grade pyrolusite, rich in manganese dioxide is used as a depolarizer in dry battery manufacture. In the absence of natural ore of suitable grade, manganese dioxide is prepared by chemical or electrolytic processes.

Pyrolusite of good quality (MnO_2, >85%) is used as a decolourizer in glass manufacture; it is added to the batch in small quantities (5–30 lb./ton of glass sand); when used in excessive quantities it imparts a pale amethyst to nearly black tint. In the ceramic industry, pyrolusite is used widely in glazes and enamels; it is used as a colouring agent in grey speckled and black bricks, and in brown pottery and tiles. Manganese dioxide is also an ingredient of match head compositions (Khedker, 158; *Indian Miner.*, 1958, **12,** 236).

High grade pyrolusite is used as a starting material in the manufacture of manganese salts. Manganates and permanganates find use as disinfectants and oxidizing agents in chemical processes; they are employed in the purification of zinc solutions in lithopone manufacture. Manganese metal is obtained by the electrolysis of manganese sulphate or chloride. Manganese sulphate is used also in the manufacture of hydroquinone. In the U.S.A., farmers add manganese sulphate to calcareous soils and soils containing high concentrations of organic matter to improve the yields of tomatoes, potatoes, beans and maize.

Oxides of manganese, and particularly organic manganese compounds, e.g. naphthenate, linoleate, and oxalate, are used as driers for vegetable oils in the paints and varnish industry. Manganous oxide (manganese green), manganese metaphosphate (manganese violet) and barium manganate are used as pigments. Manganese phosphate is used in protective coatings for steel.

TABLE 3—SPECIFICATIONS OF MANGANESE ORES FOR VARIOUS USES

Use	Origin of ore	Grade	Specifications
Leclanche cells & batteries and also certain chemicals & pigments*	Dongri Buzurg (Maharashtra)	Low ferruginous	MnO_2, 88-89; SiO_2 (max.), 1.5; Fe (max.), 1.0%
		Standard peroxide	MnO_2, 85-86; SiO_2 (max.), 3.0; Fe (max.), 3.0%
		Peroxide smalls	MnO_2 (min.), 84; SiO_2 (max.), 3.0; Fe (max.), 3.5%
	Keonjhar & Bonai (Orissa)	First	MnO_2 (min.), 90; SiO_2, 0.7-1.0; Fe, 0.30-0.75%
		Second	MnO_2 (min.), 88; SiO_2, 0.7-1.0; Fe, 0.75-1.00%
		Third	MnO_2 (min.), 87; SiO_2 (max.), 1.0; Fe (max.), 1.0%
		Fourth	MnO_2 (min.), 84; Fe (max.), 2.5%
Ferromanganese, manganese alloys, manganese metal, etc. and such chemicals as do not require the use of ore of high MnO_2 content*	Dongri Buzurg (Maharashtra)	Run of mine	Mn (min.), 51; Fe (max.), 6.5; SiO_2 (max.), 5.0; P (max), 0.3%
		First	Mn (min.), 48; Fe (max.), 7.5; SiO_2 (max.), 9.0; P (max.), 0.15%
		Second	Mn, 45-48; Fe (max.), 9.0; SiO_2 (max.), 11.0; P, 0.15-0.30%
	Orissa & Singhbhum	First	Mn (min.), 48; Fe, 4-8; SiO_2, 3-8; P, 0.15-0.20%
		Second	Mn, 45-48; Fe, 8-12; SiO_2, 5-8; P, 0.15-0.20%
		Third	Mn, 38-40; Fe, 11-19; SiO_2, 5-13; P, 0.15-0.20%
		Fourth	Mn, 30-35; Fe, 19-25%
	Sandhur		Mn, 35-42; Fe (max.), 16; SiO_2 (max.), 2; P, 0.02-0.05%
	Gujarat	First	Mn (min.), 48; Fe (max.), 5; SiO_2 (max.), 6; P (max.), 0.24%
		Second	Mn, 46-48; Fe, 5-6; SiO_2, 6-10; P, 0.24-0.26%
		Third	Mn, <46; Fe, 6-7; SiO_2, 10-11; P, 0.25-0.27%
Glass†		Ordinary	MnO_2, 85-90; Fe_2O_3, <0.75%
		High quality	MnO_2, >90; Fe_2O_3, <0.5%
Chemical industry‡		Type A: oxidizing agent	MnO_2, ≮80; Fe (max.), 3%
		Type B: manufacture of $KMnO_4$ and other permanganate chemicals	MnO_2 (min.), 85; Fe (max.), 3; SiO_2 (max.), 3; Al_2O_3 (max.), 3; P (max.), 0.10; As (max.), 0.05%

* IS: 372 and 373 (1952).

† Johnstone, 320.

‡ U.S National Stockpile Specification P-81 (1950).

PRODUCTION AND TRADE

India is the second largest manganese ore producing country in the world, the first being Russia. During the years 1955–59, the average annual world production of manganese ore was 11.86 million metric tons of which India's share was c. 13% (Table 1). In the early decades of the century, India's production exceeded that of the Soviet Union. Table 4 gives the production of manganese ore in India since 1949. Table 5 gives the State-wise distribution of production during recent years. Table 6 gives the production in 1959 according to grades.

Consumption—The bulk of the ore produced in India is exported; only a small quantity (c. 15%) is

TABLE 4—PRODUCTION OF MANGANESE ORES IN INDIA
(Qty in thousand metric tons and val. in million Rs.)

Year	Qty	Val.
1949-53 (av.)	1,257	76
1954	1,436	113
1955	1,609	108
1956	1,764	130
1957	1,681	141
1958	1,276	116
1959	1,178	92
1960†	1,182	82

† Provisional.

TABLE 5—STATE-WISE PRODUCTION OF MANGANESE ORES*
(Qty in metric tons and val. in thousand Rs.)

	1958		1959		1960†	
	Qty	Val.	Qty	Val.	Qty	Val.
Gujarat	324,698	44,019	69,288	5,456	77,008	5,366
Maharashtra			188,927	24,140	185,826	22,826
Madhya Pradesh	300,037	36,646	226,427	27,340	218,265	23,627
Mysore	253,890	12,532	248,634	11,412	293,474	11,101
Orissa	358,667	21,270	395,657	22,031	342,896	17,192
Bihar	22,275	496	27,438	741	18,729	641
Other States	16,528	565	21,584	495	45,922	1,036
Total	1,276,095	115,528	1,177,955	91,615	1,182,120	81,789

* *Indian Minerals Yearbook*, Indian Bureau of Mines, 1959, 221; *Provisional Estimates of Mineral Production in India*, Indian Bureau of Mines, 1960, 80; † Provisional.

TABLE 6—PROVISIONAL GRADE-WISE PRODUCTION OF MANGANESE ORE IN 1959*
(Qty in metric tons)

State/Grade	MnO_2	Above 48% Mn	44-48% Mn	42-44% Mn	38-42% Mn	Others	Total†
Andhra Pradesh				670	194	11,014	11,878
Bihar			583	1,560	3,147	22,148	27,438
Gujarat & Maharashtra	4,932	89,899	102,248	59,918	1,218		258,215
Madhya Pradesh		133,341	79,806	13,146	6,957	14,367	247,617
Mysore		2,754	18,084	52,823	118,437	48,836	240,934
Orissa	1,265	12,331	92,988	65,893	94,820	128,360	395,657
Rajasthan				896	4,019	199	5,114
West Bengal				..	..	580	580
Total	6,197	238,325	293,709	194,906	228,792	225,504	1,187,433
Percentage of total production	0.5	20.1	24.7	16.4	19.0	19.3	100

* *Indian Minerals Yearbook*, Indian Bureau of Mines, 1959, 222.
† The totals for several States have been subsequently revised (Table 5), but as revised grade-wise production figures are not yet available the provisional figures have been given.

consumed within the country. The iron and steel industry and the ferromanganese industry are the main consumers of the ore in India (Table 7). The total annual consumption of the ore in non-metallurgical industries has been estimated at 4,000 tons (Madan, 104 : Narayanan & Subrahmanyan, 14).

Exports -India exports 40-45% of its annual production of manganese ore to U.S.A. (Table 8); smaller quantities are supplied to U.K. and Japan. Table 9 gives the exports, classified according to grades, in 1960-61. The Government of India have set up an export promotion council to devise measures for improving the exports ; export duty on manganese ore has been abolished from November 1958 and rebate on railway freight is being granted from September 1959 for transporting medium and low-grade ores from stations situated over 200 miles from ports of export. The royalty rates have also been cut from 12½% to 7½% of sale price at pit's mouth in the case of high grade ore and from 10% to 5% in the case of low grade material. The export of ore is

TABLE 7—CONSUMPTION OF MANGANESE ORE BY STEEL COMPANIES AND PRODUCTION OF FERROMANGANESE IN INDIA*
(Qty in tons)

Year	Consumption by steel companies Qty	Production of ferromanganese Qty
1949 53 (av.)	77,945	14,359
1954	114,287	36,725
1955	42,011	6,651
1956	89,585	24,268
1957†	32,995	4,620
1958†	91,000	44,984
1959†	236,000	60,000
1960†	323,000	86,000

* Sinha, *Indian Min. J.*, 1958, **6**(6), 19, 20.
† In metric tons.

TABLE 8—EXPORTS OF MANGANESE ORES FROM INDIA
(Qty in thousand tons and val. in thousand Rs.)

	Qty	Val.
1948/49-1953/54*	894	106,817
1953 54	1,624	246,263
1954 55	1,022	130,588
1955 56	984	110,495
1956 (April Dec.)	514	86,819
1957†	1,715	319,291
1958†	960	155,844
1959†	985‡	127,417
1960 61	1,167‡	140,359

* Excluding ferruginous ores.
† Including concentrates ; ‡ In metric tons.

TABLE 9—GRADE-WISE EXPORTS OF MANGANESE ORES AND CONCENTRATES IN 1959 AND 1960-61
(Qty in thousand metric tons and val. in thousand Rs.)

	1959		1960 61	
	Qty	Val.	Qty	Val.
First grade (Mn, 48% and over)	363.7	63,946	408.7	65,181
Second grade (Mn, 35 48%)	558.8	59,426	628.2	67,686
Ferruginous (Mn, less than 35%)	57.4	2,824	125.4	6,457
Peroxide ore (Standard, MnO_2, 86%)	0.5	237	1.4	541
Peroxide ore (MnO_2, below 86%)	2.2	657	1.5	367
Others†	2.3	327	1.7	127
Total	984.9	127,417	1,166.9	140,359

† Including manganite.

TABLE 10—PRICES OF MANGANESE ORES*
(Rs. per metric ton)

Ore grade Mn%	f.o.b. Calcutta 1959	f.o.b. Calcutta 1960	f.o.b. Madras 1959	f.o.b. Madras 1960	f.o.b. Visakhapatnam† 1959	f.o.b. Visakhapatnam† 1960
46 48	137.79 149.60	137.79 147.63	144.10 154.60	147.63 150.91	147.70 157.50	137.79 157.47
42 44	93.53 108.20	93.50 103.34	91.41 116.20	n.q.	108.20 132.90	108.26-118.00
38 40	73.84 84.18	70.00 78.75	79.75 93.53	81.20 82.00	78.75 83.68	78.75

* *Provisional Estimates of Mineral Production in India*, Indian Bureau of Mines, 1960, 109.
† Relate to ores containing 44 46% Mn.
n.q.- not quoted.

now being regulated and established shippers and mine owners have been allotted quotas for future exports based on the quantity exported in 1957-58. The State Trading Corporation is also taking steps to increase exports by entering into barter transactions or compensation deals with foreign countries.

Prices—The prices of manganese ores is determined by their manganese content. Table 10 gives the prices of different grades of ores in 1959 and 1960.

MANGIFERA Linn. (*Anacardiaceae*)

A fairly large genus of evergreen trees, distributed in tropical and sub-tropical parts of South-East Asia, from India and Ceylon in the west to the Philippines and New Guinea in the east, from Yunnan (China) and Indo-China in the north, to Sunda and Sulu Archipelago in the south. Three or four species are recorded in India, of which *M. indica* is by far the best known and most widely cultivated for its fruit.

M. indica Linn. THE MANGO

D.E.P., V, 146; C.P., 764; Fl. Br. Ind., II, 13; Singh, 13–19.

SANS.—*Amra, chuta*; HINDI—*Am, amb*; BENG. *Am*; MAR. *Amba*; GUJ. *Amri*; TEL.—*Mamidi, mavi*; TAM.—*Manga, mau*; KAN. *Mavu*; MAL.—*Amram, cutam, mavu.*

A large evergreen tree, 10.0-45.0 m. high, with a heavy, dome-shaped crown and a straight, stout bole; bark thick, rough, dark grey, flaking off when old; leaves linear-oblong or elliptic-lanceolate, 10-30 cm. long and 2–9 cm. wide, emitting when crushed an aromatic, resinous odour; inflorescence a large panicle, containing in some types more than 3,000 flowers; flowers tiny, reddish white or yellowish green, pungently odorous and melliferous: staminate and hermaphrodite flowers borne in the same panicle; fruit a large drupe exceedingly variable in form and size: fruit skin thick or thin, leathery, green, yellowish or red, often dotted with numerous glands: flesh (mesocarp) whitish yellow, yellow or orange, firm, soft or juicy, sub-acid or sweet, richly aromatic: fibres throughout the flesh in some types, absent or very little in others; seed solitary, ovoid-oblique, encased in a hard compressed fibrous endocarp (stone).

The mango is the most popular and the choicest fruit of India and occupies a prominent place among the best fruits of the world. Few other tropical fruits have the historic reputation that mango possesses and few others are so intimately connected with Indian folklore. It has been cultivated in India for at least 4,000 years and recent studies on the genus indicate that it probably originated in the Assam-Burma-Thailand region where truly wild mango trees, belonging to both *M. indica* and *M. sylvatica*, have been recorded. It is surmised that natural hybridization between the two species has played an important part in the evolution of the cultivated mango. Cytological observations indicate that it had an allopolyploid origin and numerous types have been differentiated by gene mutation and hybridization (Burns & Prayag, *Bull. Dep. Agric. Bombay*, No. 103, 1920; Gangolly *et al.*, 4; Singh, 1 5; Mukherjee, *Sci. & Cult.*, 1949–50, **15,** 469; *Indian J. Genet.*, 1951, **11,** 49; *Econ. Bot.*, 1953, **7,** 130; *J. Linn. Soc., Bot.*, 1949–57, **55,** 65; *Cytologia, Tokyo*, 1957, **22,** 239).

Mango occurs wild or semi-wild nearly throughout India, in tropical and sub-tropical hilly forests, particularly near nullahs and ravines. It is common in sub-tropical Himalayas, hills of western and eastern ghats and the forests of Central India, Bihar, Orissa, Assam and Andaman Islands. It is grown in plantations and orchards, but more often in homeyards, field borders and roadside avenues (Mukherji, *Lloydia*, 1949, **12,** 73; Singh, 6).

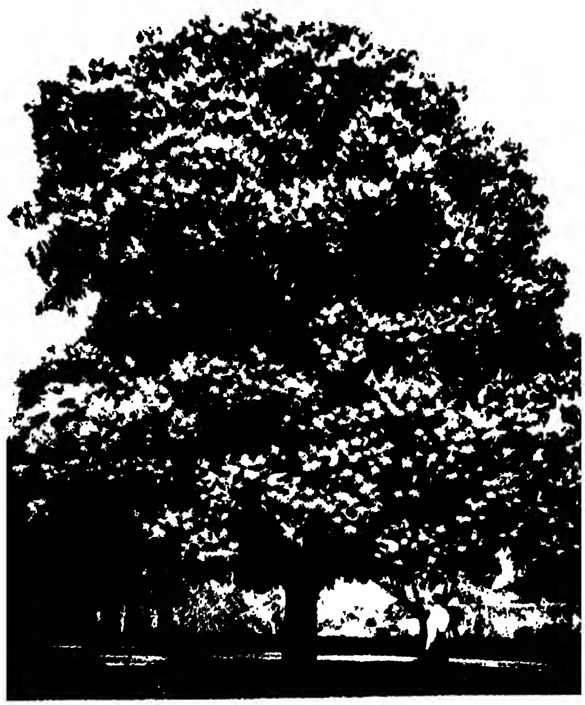


FIG. 90. MANGIFERA INDICA—TREE IN BLOOM

FIG. 91. MANGIFERA INDICA—FLOWERING BRANCH

Mango is by far the most important fruit crop of the country, occupying about 60% of the total area under fruits. The total area under mango is estimated at 2 million acres. The largest acreage is in Uttar Pradesh; Bihar ranks second; other important mango growing areas are distributed in West Bengal, Andhra, Madras and the west coast. Table 1 gives the distribution of area and production of mango fruits in different States.

The introduction of mango in other parts of the world is comparatively recent. It is now cultivated in southern China, Malaya, Indonesia, warmer parts of Australia, Philippines, Hawaii and West Indies, Madagascar and along the coast of tropical Africa. In N. America, it is grown to a limited extent in Florida and California (Burns & Prayag, loc cit.; Pope, *Bull. Hawaii agric. Exp. Sta.*, No. 58, 1929; Hayes, 132; Singh, 8–10).

The mango tree tends to live to a great age. Giant trees, over 100 years old, have been recorded in West Bengal, Bihar, Bombay and Punjab; a tree in Chandigarh (Punjab) has a trunk 9.6 m. in girth and a crown spreading over an area of 2,250 sq. meters and yields annually c. 450 maunds of fruit. A similar tree in the Philippines, which is also over 100 years old, is reported to have a crown covering an area of 1,350 sq. meters and produces annually 10,000–15,000 fruits, with a peak harvest of 35,000 fruits [Randhawa, *Indian Fmg*, 1949, **10**, 257; Bhadran, *Indian Hort.*, 1956–57, **1**(4), 24; Crucillo, *Philipp. agric. Rev.*, 1928, **21**, 82].

Varieties—Mangoes are grouped under two broad categories: seedling types (wild and cultivated) and horticultural clones, propagated by budding or grafting. Nearly three-fourths of the total area under mango in India are planted with seedling progenies, but they are not so well known or commercially important in India as in South-East Asia. Seedling types are prolific yielders but the yields are not consistent year after year. Wild forms occur in tropical and mixed forests in Andamans, in the evergreen forests of Khasi hills, valleys of Assam, Sikkim, sub-Himalayan tracts of U.P., and along the western

TABLE 1—ESTIMATED AREA AND PRODUCTION OF MANGOES IN DIFFERENT STATES (1956)*

	Area (acres)	% of total area	Yield/acre (md.)	Total annual production** (md.)
Uttar Pradesh	767,691	40.2	70.0	53,738,370
Bihar	217,517	11.4	32.7	7,112,806
Andhra Pradesh	185,858	9.8	50.2	9,330,072
West Bengal	180,776	9.5	137.2	24,802,467
Orissa	167,177	8.8	33.7	5,633,865
Kerala	113,341	5.9	100.0	11,334,100
Madras	62,819	3.3	74.5	4,680,016
Bombay	54,854	2.9	46.6	2,556,196
Madhya Pradesh	50,903	2.7	71.2	3,624,294
Mysore	45,276	2.4	185.4	8,394,170
Tripura	24,000	1.3	98.7	2,368,800
Punjab	17,456	0.9	81.7	1,426,155
Assam	15,000	0.7	19.0	285,000
Laccadive Islands	4,664	0.2	98.7	460,337
Jammu & Kashmir	472	(a)	98.7	46,586
Himachal Pradesh	208	(a)	98.7	20,530
Rajasthan	60	(a)	98.7	5,922
Total	1,908,072	100.0	71.2	135,819,686

* *Marketing of Mangoes in India, Agric. Marketing Ser.*, No. 77, 1958, 245–46.
** For the year 1954–55. (a) Negligible.

Indian Coun. Agric. Res., New Delhi

MANGIFERA INDICA — TREE IN FRUIT

ghats in S. India. They yield fruits of various shapes and sizes, some of them attaining the size of cultivated fruits (Mukherjee, *Sci. & Cult.*, 1949–50, **15**, 469; Singh, 91–92).

Two races of seedling mangoes are recognized, *monoembryonic* and *polyembryonic*. When grown from seed, monoembryonic mangoes do not breed true to type; the embryo is generally a hybrid, being the product of natural crossing. In polyembryonic mangoes, except for one embryo produced by cross pollination, the rest are nucellar; they are vegetative growths of ovular tissue and give rise to plants which breed true to the parent. The distinction into monoembryonic and polyembryonic types, however, is not inviolable; polyembryony may occur occasionally among monoembryonic types and polyembryonic types have produced at times only one seedling. In India, almost all types of mangoes are monoembryonic. Polyembryonic types are found only in Malabar; about ten types are known, of which the most important are *Olour* and *Chandrakaran*. The types indigenous to the moist tropics of South-East Asia are on the other hand mostly polyembryonic; the more important among them are *Cambodiana* of Indo-China and *Carabao* and *Pico* of the Philippines (Wester, *Bull. Bur. Agric. Philipp.*, No. 18, 1920; Naik, 123; Gandhi, *Farm Bull., Indian Coun. agric. Res.*, No. 6, 1955; Singh, 22–23; Sen & Mallik, *Indian J. agric. Sci.*, 1940, **10**, 750; Naik & Gangolly, 32; Hayes, 140; Sachar & Chopra, *Indian J. agric. Sci.*, 1957, **27**, 219; Maheshwari & Ranga Swamy, *Indian J. Hort.*, 1958, **15**, 275).

A large number of mango types, estimated at over 1,000, are grown in various parts of India, each having its own peculiar taste, flavour and consistency of pulp. Throughout the centuries of cultivation, clonal strains have been selected from zygotic seedlings and vegetatively propagated as standard varieties. Quite often one and the same type has been grown under different names in different parts of the country. Several attempts have been made to describe and classify them with reference to the size, shape and quality of the fruits, particularly with a view to clarify their nomenclature. A comprehensive survey of types grown in India has been made and 210 types have been described with reference to morphological and horticultural features. Recently attempt has been made to describe them according to a prescribed schedule; in all 77 types have been described from India and 24 from outside countries. Only a few among them are of commercial importance; the principal horticultural and fruit qualities of some of them are given in Table 2. Table 3 gives a list of important mango types grown in different States (Woodhouse, *Quart. J. Dep. Agric. Beng.*, 1908–09, **2**, 168; Burns & Prayag, loc. cit.; Allan, *Bull. Dep. Agric. U.P.*, No. 13, 1943; Mukherjee, *Bull. bot. Soc. Beng.*, 1948, **2**, 15; Naik, 123; Naik & Gangolly, 33–34; *The Mango: A Souvenir*, Dep. Agric. Hyderabad, 1954, Statements, 2–11; Singh & Singh, I & II, 1956; Gangolly *et al.*, 7–8; Singh, 93–142).

While almost all types currently grown in India are selected from natural crosses, attempts have been made to breed improved types by hybridizing parental types with known qualities. Some intervarietal hybrids with improved characteristics have been evolved and some of them exhibit the good qualities of the parents and also hybrid vigour. Grafts raised from them have generally given higher yields and the bearing period is much earlier than the seedlings themselves (Naik, *Indian J. agric. Sci.*, 1948, **18**, 35; Sen *et al.*, *Indian J. Hort.*, 1946, **4**, 4; Singh, ibid., 1954, **11**, 16; Naik *et al.*, ibid., 1958, **15**, 159; Rao & Rangacharlu, ibid., 1958, **15**, 173).

Cultivation

The mango flourishes in tropical or nearly tropical climates with a mean shade temperature of *c.* 80°F., minimum temperature above freezing point and abundant moisture in the atmosphere. It grows well in humid as well as dry climates, but yields better in regions with a rainfall of 75–250 cm. from June to September, followed by a rainless period of about 8 months. Rain, fog or cloudy weather at the time of flowering (November to February) affects fertilization and fruit setting and favours the onset of pests and diseases. Similarly, heavy rain during the maturing and ripening of fruits causes damage to the crop (Cheema *et al.*, 50–51; Naik, 121; Gangolly *et al.*, 465; Gandhi, loc. cit.).

The tree does not bear abundant fruit in the humid zones of lower Bengal, Assam, Kerala and south-east Madras, since there is no chilly winter in these regions. Further, due to the occurrence of south-west and north-east monsoons, the climate remains continuously wet for over eight months in the year and flowering is sporadic and meagre, and blossoms and fruits are often destroyed by anthracnose. The mango cannot stand frost and, therefore, does not thrive in the hills of Punjab, Uttar Pradesh and the temperate regions of Himachal Pradesh and Kashmir above 900 m. In the frost-free plains and

TABLE 2—CHARACTERISTICS OF SOME IMPORTANT COMMERCIAL TYPES OF MANGOES CULTIVATED IN INDIA*

Type	Main areas of cultivation	Fruit characteristics	Keeping quality	Fruiting season	Remarks
1. Allumpur Baneshan	Andhra Pradesh, Madras	Large, oblong to oblong-oval; primuline yellow, flesh firm, maize yellow, juicy	Good	Mid-season	Poor to medium bearer; very good edible quality
2. Alphonso *Badami, gundu, appas, khader*	Konkan (Maharashtra), Mysore, Madras, Kerala & Andhra Pradesh	Medium, ovate-oblique; capucine yellow; flesh firm, capucine yellow with abundant juice	Good	Mid-season	Medium to heavy bearer; excellent quality
3. Bangalora *Totapuri, collector, kili-mukku*	Madras, Andhra Pradesh, Mysore	Medium, oblong with necked base & prominent beak; skin thick, lemon chrome colour; flesh firm, mustard yellow, juice scanty	Good	Mid-season	Heavy bearer; poor to medium quality
4. Banganpalli *Baneshan, chaptai, safeda*	Madras, Andhra Pradesh	Large, obliquely oval, base obliquely flattened; primuline yellow; flesh firm to meaty, maize yellow, juice moderate	Good	Mid-season	Heavy bearer; good quality
5. Bombay Yellow *Bombai*	Uttar Pradesh, Bihar	Medium, ovate oblique, base obliquely flattened; golden yellow; flesh firm, capucine yellow, moderately juicy	Medium	Early	Medium bearer; good edible quality
6. Dusehri *Dashehari aman, nirali aman, kamyab*	Uttar Pradesh, Punjab & Delhi	Small to medium, oblong to oblong-oblique; primuline yellow; flesh firm, capucine yellow; juice scanty to moderate	Good	Mid-season	Regular heavy bearer; good quality
7. Fazli *Fazli malda*	West Bengal, Uttar Pradesh, Bihar	Large, oblong oblique, cerro green; flesh firm, cosse green when mature & primuline yellow when fully ripe	Good	Late season	Heavy bearer; good quality
8. Gulab Khas	Bihar	Small to medium, oblong oblique, base necked to tapering; cadmium yellow with a blush of firefly on shoulders; flesh firm, cadmium yellow; juice moderate to abundant	Very good	Mid-season	Heavy bearer; very good edible quality
9. Langra *Banarsi langra*	Uttar Pradesh, Bihar	Medium, ovate; lettuce green; flesh firm to soft, lemon yellow with strong flavour; moderately juicy	Medium	Early to mid-season	Heavy bearer; very good quality
10. Malda *Bombay green*	Uttar Pradesh & many other areas of Indo-Gangetic plain	Medium, ovate-oblong to oblong reniform; spinach green; flesh firm to soft, mikado orange; moderately juicy	Medium	Early	Heavy bearer; fruit of good quality
11. Mulgoa	Andhra Pradesh, Maharashtra, Mysore & Salem dist. of Madras	Large, roundish oblique; primuline yellow; flesh firm, mustard yellow; juice moderate to abundant	Good	Often late	Poor bearer; fruit of very good edible quality
12. Neelum	Drier districts of Madras & Andhra Pradesh	Medium, ovate-oblique; saffron yellow; flesh firm primuline yellow; moderately juicy	Very good; stands long transport	Often late; sometimes twice a year	

TABLE 2- *contd.*

Type	Main areas of cultivation	Fruit characteristics	Keeping quality	Fruiting season	Remarks
13. Olour	Kerala	Medium, oval; capucine yellow; flesh soft, moderately fibrous, capucine yellow; juice moderate to abundant	Medium to good	Very early season (Febr.-Mar.)	Polyembryonic; heavy-bearer; moderately resistant to winds & hoppers
14. Pairi *Raspuri, peter, nadusalai, grape, goha bunder*	Central districts of Madras, Mysore, Andhra Pradesh, Maharashtra & Kerala	Medium, ovate; apricot yellow; flesh soft, fibreless, primuline yellow; juice abundant	Medium to poor	Early season crop	Heavy yielder; fruit of good quality
15. Rajapuri	Gujarat	Medium to large, ovate to ovate-oblong; deep chrome; flesh firm, prinnard yellow; moderately juicy	Medium	Early to mid-season	Heavy & regular bearer
16. Rumani	East coast districts of Madras	Medium, apple-shaped; primuline yellow with a blush of red on shoulders; flesh firm to meaty, primuline yellow; moderately juicy	Good; stands long transport	Mid-season to late, often bears an off season crop	Heavy bearer
17. Safeda Lucknow	Uttar Pradesh	Large, ovate; capucine yellow; flesh soft, sparingly fibrous, primuline yellow; juice abundant	Medium	Late season crop	
18. Safdar Pasand	West Bengal, Bihar	Medium, oblong to oblong oblique; skin thick, smooth golden yellow; flesh firm, fibreless, capucine yellow; moderately juicy	Medium	Early season	Very productive, regular bearer
19. Samarbehisht Chowsa *Chausa, khajri*	Uttar Pradesh	Medium, ovate to oval oblique; canary yellow; flesh firm, amber yellow; moderately juicy	Medium to good	Mid to late season	Heavy bearer; good quality fruits
20. Suvarnarekha *Sundri, latsundri*	Andhra Pradesh	Medium, ovate-oblong, light cadmium with a blush of jasper red; flesh fibreless primuline yellow	Good	Early season	Heavy bearer
21. Vanraj	Baroda in Gujarat	Medium to large, ovate oblong; deep chrome with a blush of jasper red on shoulders; flesh firm to soft, fibreless, cadmium; juice abundant	Good	Mid to late season	Medium productive; regular bearing; fruit of good quality
22. Zardalu	Bihar, Uttar Pradesh	Medium, oblong to obliquely oblong; golden yellow; flesh firm to soft, sparingly fibrous, capucine yellow; moderately juicy	Medium	Mid-season crop	Medium to heavy bearer
23. K.O. 7/5 (Himayuddin × Neelum)	Rayalaseema in Andhra Pradesh	Medium to large, oblong to oblong-oval; skin leathery, yellowish; flesh firm, fibreless	Keeps well	Mid to late season	Heavy bearer; very good quality
24. K.O. 11	Do.	Large, ovate; skin roughened to slightly warty, yellowish, flushed with coral red; flesh soft, fibreless		Mid-season	Medium to heavy bearer

* Gangolly *et al.*, 38 454; Naik, 126–41; *Marketing of Mangoes in India, Agric. Marketing Ser.*, No. 77, 1958.

TABLE 3—IMPORTANT MANGO TYPES CULTIVATED IN DIFFERENT STATES*

State	Type	Areas (districts) of cultivation
Punjab & Delhi	Alphonso Punjab, Dusehri, Langra, Malda Handle, Kachmuha, Khangari Bacha, Sehroli, Surkha Panditwala (Sindhuria)	Hoshiarpur, Ambala, Gurdaspur & Karnal dist.; Delhi State
Uttar Pradesh	Amin Heera, Amin Ibrahimpur, Amin Khurd, Amin Sahai, Amin Tehsil (Prince), Anopan, Aziz Pasand, Bagal Sahai, Baramasia, Bhaduriya, Bombay Green (Malda), Bombay Yellow, Buddu ka Kelwa, Dusehri, Fajri, Fajri Zafrani, Fakirwala, Fazli Malda, Gopal Bhog, Gulab Jaman, Hushnara, Inayat Pasand, Kandel, Khasa Ibrahimpur, Kishenbhog, Langra, Malda Handle, Nisarpasand, Raspunia, Rataul, Rehmat Khas, Safeda Calcutta, Safeda Lucknow, Safeda Malihabad, Sakkarchina, Samarbehisht Alibagh, Samarbehisht Chowsa (Kajri), Samarbehisht Rampur, Sangtra, Sehroli, Shamsul-asamar, Taimuria, Zafran, Zardalu	Gorakhpur, Sultanpur, Ghazipur, Rae Bareli, Pratapgarh, Allahabad, Faizabad, Barabanki, Jaunpur, Sitapur, Deoria, Basti, Gonda, Kheri, Hardoi, Meerut, Saharanpur, Bareilly, Kanpur & Lucknow dist.
Bihar	Alphonso Bihar, Bathua, Bharat Bhog, Bombai (Malda), Bombay Yellow, Buddu Ka Kelwa, Dophool, Fajri, Fazli Malda, Gulab Khas, Hushnara, Khas-ul Khas, Kishenbhog, Langra, Safdar Pasand, Sakkarchina, Samarbehisht Chowsa, Sukul, Surkh Burma, Taimuria, Zardalu	Muzaffarpur, Darbhanga, Saran, Shahabad, Champaran, Patna, Bhagalpur & Purnea dist.
West Bengal	Bhawani Chowras, Bombai (Malda), Bombay Yellow, Brindabani, Dophool, Fajri, Fazli Malda, Fazli Zumko, Himsagar, Inayat Pasand, Kanchamitha, Kishenbhog, Kohitoor, Langra, Panja Pasand, Ranee Pasand, Safdar Pasand, Shadwala, Shah Pasand, Zardalu	Malda, Murshidabad, Burdwan, 24-Parganas, Nadia & Hooghly dist.
Assam	Mostly seedling types	Scattered all over State.
Orissa	Mostly seedling types, and Suvarnarekha, Banganpalli, Neelum, Langra, Dophool	Sambalpur, Ganjam, Koraput, Cuttack & Puri dist.
Madhya Pradesh	Mostly seedling types (Wangya, Kharbooza, Khobrya, Shendriya, Shrawanya); Pairi, Alphonso, Bombai Malda, Langra	Drug, Jabalpur, Bilaspur, Raipur, Hoshangabad & Bastar dist.
Andhra Pradesh	Allumpur Baneshan, Alphonso, Amlet, Ashraf-us-Samar, Athimadhuram, Azum-us-Samar, Bangalora, Banganpalli, Cherukrasam, Chinnarasam, Dondakayalumanu, Doodia, Imam Pasand (Himayuddin), Jehangir (Umdra), Janardhan Pasand, Kalepad, Kintalvanipeta (Bombili Punasa), Kolanka Gova, Kathapalli Kobbari, Mulgoa (Lal, Safed, Yerra), Murshidabad, Nazeem Pasand, Nazuk Pasand, Neelum, Pairi (Peter), Panakalu, Panchadarakalasa, Peddakalepadu, Pedda Rasam, Pulihora, Rajumanu, Sakkar Gutli, Suvarnarekha (Sundri), Swarapadu	Visakhapatnam, Chittoor, East Godavari, Krishna, Cuddapah, West Godavari, Nalgonda, Hyderabad, Medak & Mahbubnagar dist.
Madras	Allumpur Baneshan, Alphonso (Gundu), Amlet (Manoranjani), Bangalora (Kili mukku), Banganpalli, Jailor, Jehangir, Kalepad (Katti Neelum), Khudadad, Mulgoa, Neelum, Padiri, Pairi (Nadusalai), Pulihora (Colour), Rumani, Salem Bangalora, Sindhura	N. Arcot, Salem, Chingleput & Madurai dist.
Mysore	Alphonso (Badami), Bangalora (Totapuri), Kalepad (Kallapady Khudadad, Mankurad, Mulgoa, Mundappa, Neelum, Pairi	Kolar, Bangalore, Tumkur, Mysore, Gulbarga, Dharwar, Kanara, Chitaldrug, Hassan, Chikmagalur & Mandya dist.
Kerala	Alphonso, Amini, Chandrakaran, Hamlet, Mundappa, Khudadad, Olour, Pairi, Puttu	All districts
Maharashtra	Amini, Alphonso, Borsha Kalamsar, Fernandin, Mankurad, Mulgoa, Pairi, Shendriya	Ratnagiri, Nasik, Satara, Kolaba, Aurangabad, Bir, Parbhani & Osmanabad dist.
Gujarat	Alphonso, Borsha Kalamsar, Cowasji Patel, Dadamiyo, Jamadar, Rajapuri, Salebhoy Amidi, Sardar, Shendriya, Vanraj	Surat & Kaira dist.

**Marketing of Mangoes in India, Agric. Marketing Ser.*, No. 77, 1958; Gangolly *et al.*, 38-454.

hills of Peninsular India, the mango grows from sea level up to 1,200 m., but is commercially unsuccessful at elevations above 900 m. (Singh, 80).

Mangoes thrive in parts of North India where temperatures as high as 115–120°F. prevail during the summer; however, high temperatures accompanied by strong winds damage and blow away the fruits. Strong wind breaks, preferably of shisham (*Dalbergia sissoo*) and other trees, are planted to the south-west of mango plantations to arrest the winds (Gangolly *et al.*, 478; Singh, 221).

Soil—The mango thrives in a wide variety of soils. It grows in rich clayey loams, as well as on poor, sandy and gravelly soil, provided it is fairly deep and well drained. Some of the best mango groves are found in the Indo-Gangetic plains and also on the banks of rivers in Peninsular India, where the soil is rich alluvial loam of great depth. It does not grow and fruit well if the subsoil is rocky, limey or clayey. In the mountainous regions of western and southern India, trees growing in shallow soils, less than 90 cm. deep, remain stunted and are short-lived; those planted 1.5 m. deep in loamy, medium black soil, overlying a porous, murum (disintegrating trap rock) substratum give good results. Fruits of the best quality are produced on loamy soil, 90 cm. in depth, containing 5–10% of lime and enough peroxide of iron to give the soil a reddish tinge (Burns & Prayag, loc. cit.; Allan, loc. cit.; Cheema *et al.*, 49; Singh, 84–87).

Propagation—The mango is easily propagated from seed, but this method is not satisfactory for establishing commercial orchards of choice types, since seedlings tend to be variable and often bear fruits which are inferior in quality to those of the parent; further, seedling trees are slow to come into bearing. To ensure fruit quality and early productiveness, choice types are propagated by grafting (Singh, 143–45).

Inarching or simple approach grafting is the method commonly practised all over India. The root-stock is raised from seeds of any type selected for its vigour and when about a year old, it is grafted with a branch of the scion tree. Since mango seeds lose their germinating power within 20–30 days, they are sown as soon as they are extracted from ripe fruits. The best time for sowing is the commencement of the monsoon, June or July. Seeds may be sown in pots or they may first be sown in beds and then transplanted into pots after two months. Potted seedlings are kept under partial shade for about one year and when they have attained a height of c. 45 cm. and a thickness of 6–12 mm., they are ready for grafting. The commencement of monsoon in light rainfall tracts and the end of monsoon in heavy rainfall tracts are the most suitable periods for inarching.

Potted seedlings are carried near the scion tree and elevated on a scaffolding to meet the branches. A one year-old terminal twig, 45–60 cm. in length, is chosen for inarching; the thickness of the scion branch should be nearly the same as that of the stock. A thin slice of bark and wood, c. 5.0 cm. long and 0.5 cm. broad and 2 mm. deep, is removed from the stock as well as the scion, the two cut surfaces are closely adpressed and the combination tied and wrapped. After about two months, when organic union is complete the scion branch is cut below the graft point, the severence being effected gradually and in stages. The graft thus prepared is nursed, hardened and cared for in a shaded place for about six months before it is planted out in the field (Gandhi, loc. cit.; Gangolly *et al.*, 468; Singh, 153–56).

About two years are required for preparing potted inarch grafts. To minimize the expense and time involved, inarching of younger seedlings has been suggested. Successful results have been obtained by inarching 3 weeks old seedlings to newly sprouted scion shoots in the Philippines, while in Poona, two months old seedlings have been inarched to scions of the same age. Inarch grafts have been made in about 8 weeks by grafting 30 days old seedlings (Wester, loc. cit.; Burns & Prayag, loc. cit.; Singh, *Science*, 1951, **114**, 393; Singh, 157).

Air-layering or marcotting has also been tried with success, particularly with application of hormones, like α-naphthaleneacetic acid and β-indoleacetic acid (Garg, *Indian J. Hort.*, 1954, **11**, 147; Rangacharlu & Rao, *Andhra agric. J.*, 1956, **3**, 269; Singh, *Proc. Amer. Soc. hort. Sci.*, 1954, **63**, 128; Rao & Rao, *S. Indian Hort.*, 1956, **4**, 54, 56; Singh, 204–05).

Tongue grafting and saddle grafting have also been suggested for the propagation of choice types. Root grafting has been tried with success, particularly for eliminating the influence of the seedling stem on the scion. Double grafting has been recommended wherever grafts are made by root grafting, top-working or budding trees of inferior quality. Double working leads to dwarfing of trees and also induces slight precocity (Naik, *Indian J. agric. Sci.*, 1948, **18**, 147; Naik, 159–62; Singh, 158–59).

Attempts have been made to replace inarching by less expensive and less cumbersome methods, in which detached pieces of scion branches are grafted over seedling rootstocks, preferably grown in a ground nursery. The methods suggested include whip-grafting, cleft-grafting, side-cleft-grafting and side-tongue grafting. The scion should be selected from a ripe terminal shoot with a whorl of plump and swollen buds at the top; a piece *c.* 15 cm. long and as thick as the stem of the rootstock seedling is cut and preserved in moist sphagnum moss until use (Burns & Prayag, loc. cit.; Singh, 165–74; Parsons, *Bull. Dep. Agric. Ceylon*, No. 90, 1937, 9; Wester, loc. cit.; Naik, *Indian J. agric. Sci.*, 1941, **11**, 736; *Indian Fmg*, 1947, **8**, 22; Pope, loc. cit.).

Though grafting by inarching is the most popular method employed in India, promising results have been obtained by budding. Three methods have been tried, viz. shield-budding, patch-budding and the Forkert method of budding. Of these shield budding by the inverted T method is the simplest and most successful. One or two year old rootstocks, grown in a nursery, are more suitable than pot-grown stocks. The percentage of successful bud-takes in shield and patch methods vary from 8 to 70% in different environments. But they have not been adopted as standard nursery practices, because of the uncertainty of bud-takes and also due to the difficulty in transplanting budded plants. On the other hand, the Forkert method of budding has given a high percentage of bud-takes and has been suggested as a commercial nursery practice suitable for replacing inarch-grafting (Burns & Prayag, loc. cit.; Ulvi, *Indian Fmg*, 1940, **1**, 223; Naik, *Indian J. agric. Sci.*, 1941, **11**, 736; Singh & Khan, *Indian Fmg*, 1943, **4**, 199; *Punjab Fr. J.*, 1943, **7**, 648; Gandhi, loc. cit.; Singh, 176–86).

Grafting of large trees—In the humid regions of the west coast of India, mango trees of large size growing on the slopes of western ghats are converted into choice varieties by *in situ* grafting during the south-west monsoon. Both crown-grafting and side-grafting have been adopted with good results. In crown-grafting, the tree is beheaded at a height of 30–60 cm. from the ground with a saw and the scion, fashioned into a wedge, is inserted in a slit prepared for the purpose in the bark. The scion is a dormant, terminal shoot, *c.* 1.2 cm. in diam. and not more than 17.5 cm. in length, with a whorl of plump and swollen buds at the top. Crown grafts done during the monsoon in Konkan and Kerala sprout satisfactorily without any special precautions. In the drier regions, however, a humid atmosphere has to be artificially created around the grafts; a miniature graft protector has been designed for this purpose. Side-grafting is similar to crown grafting, but the trunk of the stock tree above the graft joint is cut only after the union is established and the scion makes growth. Most growers prefer side-grafting as the tree is not sacrificed if the graft fails (Gandhi, loc. cit.).

The chief disadvantage of crown and side-grafting is the loss of the trunk and the top which have taken several decades to grow. The scion, grafted low down on the trunk takes many years to develop to the original size of the stock tree. To remedy this, grafting of top branches without cutting the trunk of the stock tree is recommended. The main branches of the tree are cut back to within 60–90 cm. of the main trunk. Scions of choice varieties are grafted by various methods on these beheaded branches. Bud-grafting and side-grafting and budding have all been tried. Budding has given good results where the maximum temperature ranges between 90 and 100°F. (Burns & Prayag, loc. cit.; Parsai, *Nagpur agric. Coll. Mag.*, 1951–52, **26**, 1; *Indian J. Hort.*, 1958, **15**, 203).

Planting- The best time for planting in northern and western India is July to August and in South India, July to December. The distance between plants varies according to the types grown, climatic and soil conditions. Varieties like *Dusehri* which do not grow into large trees are planted 10.5 m. apart, while *Langra* which grows into a large size is planted 13.5 m. apart. In Deccan, *Alphonso* and *Pairi* are generally planted 9–10.5 m. apart, while on the slopes of the laterite hills of Ratnagiri, *Alphonso* grafts are planted 12–18 m. at random, wherever pockets of deep soil are available. In South India, 12 m. is generally adequate, but 18 m. spacing is found necessary for vigorous types (Gandhi, loc. cit.; Singh, 221).

Mangoes are planted in pits 60 cm. in diam. and 60 cm. deep in loamy soils; in the shallow soils of hilly tracts pits are made 90 cm. wide and 90 cm. deep. Pits are dug a few weeks before the monsoon and filled before the rains break with the original soil mixed with manure; a mixture of 100 lb. of farmyard manure, 5 lb. of bonemeal and 10 lb. of wood ash is recommended for incorporation with soil. In the drier zones of North India, where white ants are present, farmyard manure is replaced by

5 lb. of neem or mahua cake. In the heavy rainfall areas of Ratnagiri, the pits are filled with alternate layers of soil and green leaves of forest trees (Gandhi, loc. cit.).

Irrigation—As a rule mango trees require irrigation only for the first three or four years. In areas with good fainfall and deep soils, it is not advisable to irrigate bearing trees during winter. Excess of moisture in the soil after October may retard flowering. On the other hand, in areas with scanty rainfall and in sandy or shallow soils, one irrigation in November or December is helpful. In North India, bearing trees are watered 4 or 5 times between the setting of fruits in February and the commencement of monsoon in June or July. This is reported to minimize fruit fall and favour the formation of large fruits. In Bombay, irrigation during flowering and fruiting periods has not proved helpful either in increasing the yield or in improving the quality of fruits (Hayes, 149; Gandhi, loc. cit.; Burns & Prayag, loc. cit.; Singh, 233).

Manuring—The best time for manuring young plants is the beginning of the monsoon. A mixture of 20 lb. of farmyard manure, 5 lb. of bonemeal and 10 lb. of wood ash is recommended for one year old plants. The dose is increased each year by 10 lb. of farmyard manure, 1 lb. of bonemeal and 2 lb. of wood ash, till the total dose per tree amounts to 100 lb. of farmyard manure, 15 lb. of bonemeal and 30 lb. of wood ash. The manure is dug into the ground in a trench 60 cm. broad and 15 cm. deep, *c.* 30 cm. away from the trunk in one year old trees. The trench is widened by about 15 cm. and its inner edge taken back 15 cm. away from the tree every year (Burns & Prayag, loc. cit.; Naik, 174; Gandhi, loc. cit.; Singh, 254).

Manuring of bearing trees of advanced age is nowhere practised in India. Available evidence indicates that annual manuring is beneficial and improves the bearing capacity of trees. Trials carried out in Bihar have shown that nitrogen determines the growth and controls the uptake of phosphoric acid and potash, and it is advisable to maintain a proper balance between nitrogen and potash. A mixture of 200 lb. of farmyard manure, 4 lb. of castor cake, 10 lb. of bonemeal, 2 lb. of ammonium sulphate and 30 lb. of wood ash is recommended [Gandhi, loc. cit.; Sen & Roy, *Proc. Indian Sci. Congr.*, 1945, pt III, 23; Roy *et al.*, *Proc. Amer. Soc. hort. Sci.*, 1951, **57**, 9; Katyal & Chadha, *Fertiliser News*, 1960, **5**(11), 16].

Other cultural practices In North India, young mango trees need protection against frost from December to early February. It is usual to cover the plants at the top and three sides with thatch, keeping the south-east side open for light and sunshine. The orchard is also protected from hot winds during summer by planting a permanent windbreak of trees on the windward side. The trees commonly planted for this purpose are: seedling mangoes, mulberry (*Morus alba*) and shisham (*Dalbergia sissoo*) in N. India and *Casuarina* sp., *Erythrina* sp. and *Pterocarpus santalinus* in S. India. The orchard is ploughed and harrowed at least twice annually to keep out weeds (Singh, 221, 227).

In the Indo-Gangetic alluvium, white ants destroy young grafts, especially during the dry weather. Ample irrigation during the dry season is necessary in such areas. For controlling white ants, DDT (0.2% water suspension) may be applied around each graft in the beginning of October; the use of castor cake, neem cake or mahua cake is also recommended (Gandhi, loc. cit.).

The mango tree naturally assumes a graceful dome-shaped form, perfectly shading the trunk. Newly planted grafts are allowed to grow unhampered for about four years before any pruning of the scion top is taken up to correct the shape. At the end of the fourth year, crossed branches, weak growths and growths appearing on the stock below the graft-joint are removed. Flowers that may appear during the first three years are removed since they seldom set fruit (Gandhi, loc. cit.).

Flowering and Fruiting

The mango produces blossoms mostly from terminal shoot buds, rarely from axillary buds. Dry weather stimulates flowering and cloudy weather and winter rains retard it. The factor that governs and controls flowering is maturity and age of seasonal vegetative growths which are produced in distinct flushes at certain times of the year. It is mostly the 8–10 months old mature shoots that produce flowers. Shoots appearing in spring and early summer cease growing at least four months prior to the blossoming season. Subsequent flushes rarely blossom towards the end of winter or the beginning of spring, which is the flowering time of the mango nearly throughout India (Gandhi, loc. cit.; Singh, 64).

Though only the spring and summer growths produce blossoms as a rule, cases of flowering have been observed in some trees due to unexpected con-

centrations of food reserves. Some varieties, called *Baramasis*, flower at any time of the year and yield sporadic crops in different seasons. In South India, certain varieties including *Neelum* and *Suvarnarekha* produce flower panicles from 3 months old lateral shoots in December or January (Gandhi, loc. cit.; Naik, 143; Naik & Gangolly, 27).

In most parts of Peninsular India, December–January is the usual time of flowering, while in many parts of North India, which experience a sharp winter, the trees flower late in January or February or even in March. Flowering continues in two or three distinct flushes for a period of 6–8 weeks on different branches of the tree and it takes five months for the fruits to mature and ripen after flowering (Gandhi, loc. cit.).

In parts of Java and the Philippines, where periods of water stress are mild and where there are more than one blossoming season, the onset of blossoms can be hastened by several weeks by "smudging". The treatment consists in lighting smoky fires for 6–17 days under the trees, a few weeks in advance of the flowering season. The presence of ethylene gas in the smoke is probably responsible for forcing the flowering. In trials conducted in Bihar, the trees instead of flowering, began to put forth vegetative growth. Other methods employed elsewhere for inducing early flowering are root exposure and pruning of end shoots. These treatments have not proved helpful in India (Galang & Agati, *Philipp. J. Agric.*, 1936, **7,** 245; Sen & Mallik, *Indian J. Hort.*, 1947, **5,** 29; Hayes, 151; Chandler, 332; Burns & Prayag, loc. cit.; Singh, 71).

In parts of Tamilnad, especially near Tenkasi in Tirunelveli district and at Kanyakumari, mango trees yield sizeable off-season crops since the rainfall in these areas is evenly distributed (Naik, 178; Lysander & Pillai, *S. Indian Hort.*, 1957, **5,** 20).

Fruit-setting—Hermaphrodite or perfect flowers are protogynous and entomophilous and are pollinated by insects. Most of the flowers open at night or early morning; some open between 7 a.m. and 10 a.m. and very few during the afternoon. The best time for insect pollination is between 7 a.m. and 1 p.m. when the anthers dehisce [Torres, *Phillip. J. Agric.*, 1931, **2,** 395; Wagle, *Agric. J. India*, 1929, **24,** 259; Bijhauwer, A.P.C., *A contribution to the knowledge of the flowering and fruiting habits of the mango tree* (*M. indica*), L.H. Veeman & Zonen, Wageningen, 1937; Musahib-Ud-Din & Dinsa, *Punjab. Fr. J.*, 1946, **10,** 35].

In western India, flies belonging to the genera *Psychonosma* and *Pyrellia* are the chief pollinating agents. In Saharanpur (Uttar Pradesh), three types of flies have been observed, viz. *Melipona* spp., *Syrphidae* sp. and *Musca domestica*. Many flowers often remain unpollinated and fail to set fruit. More than 99% of unpollinated perfect flowers drop down and of those pollinated, some drop down as shrivelled young fruits during the first four weeks after pollination. The dropping of perfect and male flowers may last from 6–32 days. For a tree to be sufficiently productive, the number of perfect flowers in its panicles should be large enough to make allowance for the mass shedding of unpollinated flowers and shrivelled young fruits. In the *Langra* variety, for instance, several well defined drops of flowers and shrivelled fruits occur at intervals of about a week and at the time of harvest in June, the yield of fruit per panicle averages to 0.38. In the case of *Alphonso* at Ratnagiri, the percentage of perfect flowers capable of developing into fruits ranges from zero to 55, the average being 10. The yield of fruit per panicle works out to 0.15–0.20 (Burns & Prayag, loc. cit.; Singh, 42–43; Maheshwari, *Curr. Sci.*, 1934–35, **5,** 97; Chandler, 332; *Leafl. Dep. Agric. Bombay*, No. 6, 1930; Wagle, *Mem. Dep. Agric. India, Bot.*, 1928, **15,** 219; Musahib-Ud-Din, *Punjab Fr. J.*, 1946, **10,** 30; Musahib-Ud-Din & Dinsa, ibid., 1946, **10,** 35).

In *Neelum* of South India, which is known for its heavy and regular cropping, perfect flowers form 16% of the total. In *Allumpur Baneshan* and *Jehangir*, the percentage is as low as 3 and 1; these types are known to bear extremely small crops in spite of their producing heavy bloom. Observations on different varieties in various parts of the world, indicate that types with less than 10% perfect flowers are by nature shy bearers. The shy bearing tendency can be overcome by hybridization with high yielding varieties. At the Fruit Research Station, Kodur (Andhra State), two such strains have been evolved, viz. *K.O. 7/5*, a cross between *Himayuddin* (*Imam Pasand*), a choice quality but shy bearing type and the prolific regular cropping *Neelum*, and *K.O. 11/13*, a cross between *Jehangir* (male) and *Suvarnarekha* (female) (Naik, 180; Naik & Gangolly, 25).

Alternate bearing—Mango trees below 10 years generally bear regular annual crops, but trees which are older show more or less rhythmic habits of producing profuse blossoms and sparse vegetative growth in one year and profuse vegetative growth

and sparse blossoms in the next. The season yielding a heavy crop is called the 'on' year and the season of lean or poor crop is called the 'off' year. This alternate bearing goes on until some adverse weather condition or a serious disease or pest upsets it. In closely spaced and neglected plantations of old trees, to which usually no cultivation is given, a heavy crop is obtained only once in five years, the intervening crops being fair and poor alternately; in some years, the trees fail to bear any crop at all. Sometimes, flowering even in 'on' years is not distributed equally over all parts of the crown; a large branch may be in its non-bearing phase while others are bearing. While most mango types in India are biennial bearers, there are a few, like the *Neelum*, which bear heavy crops every year. Regular bearing clones are also reported from Saharanpur (Gandhi, loc. cit.; Naik, 178; Singh, *Hort. Adv.*, 1957, **1**, 7; Singh, 59).

Environmental conditions, such as climate, soil moisture, cultivation, pests and diseases, may accentuate or diminish the amplitude of alternation. Generally, trees growing in rich soils and in half shady situations and those receiving abundant irrigation and excessive quantities of nitrogenous manures put forth vigorous vegetative growth and do not flower. Such trees can be made fruitful by exposing the crowns to full sunlight, withholding irrigation during the dry season and by stopping supplies of nitrogenous manures. Further, applying common salt at the rate of 10–25 lb. per tree above 15 years in age, in trenches 30 cm. wide and 30 cm. deep inhibits vegetative growth and induces flowering. Another method of forcing blossoms in over-vegetative trees is to girdle branches 15–22 cm. thick. By removing a strip of bark, *c.* 12 mm. wide, around the base, a little above the point where it joins another branch, greater quantities of carbohydrates are stored in the portion of the branch above the ring and the carbohydrate nitrogen ratio becomes more favourable for producing blossoms. Girdling should be done in August or early September, well before the blossom bud differentiation takes place (Gandhi, loc. cit.; Naik, 176; Mallik, *Indian J. Hort.*, 1951, **8**, 1; Singh, 68–71).

Close attention to orchard management, particularly with respect to manuring and irrigation, thinning of blossoms and pruning and girdling of shoots have helped in securing reasonably small crops in 'off' years. In Punjab, the removal of half the number of flower clusters from heavily laden trees in the 'on' year has been found to stimulate vegetative growth in spring and summer; a moderate crop is thus secured in the following year, which would have been otherwise an 'off' year. Deblossoming, however, has not proved helpful under all conditions and with all types of mango; it is risky in the case of shy bearing types and in areas where strong desiccating winds or storms are likely to cause severe shedding of fruits. The only solution for obtaining annual crops is to breed types which are regular bearers. Promising new strains have been evolved by crossing biennial bearing varieties with those that tend to bear heavy crops annually at Sabour (Bihar) and at Saharanpur (U.P.) [Sen, *Indian J. Hort.*, 1943, **1**, 48; *Indian Fmg*, 1944, **5**, 408; Garg, *Indian Hort.*, 1958–59, **3**(4), 27; Singh & Khan, *Indian J. agric. Sci.*, 1939, **9**, 835; Singh, 70].

Diseases and Pests

Diseases—The more serious diseases of mango are powdery mildew, anthracnose and bunchy top.

Powdery mildew, caused by *Oidium mangiferae* Berthet, affects blossoms in North, West and South India. The fungus feeds on the outer cells of flowers and young fruits which dry up and drop down. Losses due to mildew up to 20% of the total crop have been reported. The spread of the disease is favoured by rains during the flowering season. Dusting with sulphur thrice at intervals of 15 days, commencing with the emergence of inflorescence, affords effective control. Spraying Guesarol 405–50 containing 5% DDT and 50% sulphur gives good results in controlling both mildew and jassid hoppers (Cheema *et al.*, 119; Naik, 189; Gangolly *et al.*, 498; Singh, 279; Gandhi, loc. cit.).

Anthracnose, caused by *Colletotrichum gloeosporioides* Penz., is a serious disease in moist climates. It is prevalent particularly in Madras, Kerala and Assam. Dark blister-like spots appear on young twigs, leaves and blossoms; young fruits may be shed and skin of mature fruits gets disfigured by black spots; the pulp beneath the skin gets hard. The disease is controlled by spraying Bordeaux mixture 2–3 times during the fortnight preceding the opening of blossoms and also at intervals of 3–4 months during dry periods. Spraying with fish oil rosin soap in combination with starch is also recommended (Cheema *et al.*, 123; Naik, 190; Gandhi, loc. cit.; Gangolly *et al.*, 499; Singh, 267–70).

Bunchy top or abnormal inflorescence is a common malady, for which the causal organism has not been

identified with any certainty. The flowers become crowded on short thick stems and develop elongated discs; they seldom set fruit. The malady is widespread, but it is particularly serious in the hot plains of North India. A mite *Eriophyes* has been found to be associated with the malformation in Poona; eradication of infected shoots in four successive years resulted in the disappearance of the disease. Two other mites *Tyrophagus castellanii* Hirst and *Typhlodromus asiaticus* Evans have also been reported. The only preventive measure is to remove and burn affected inflorescences as soon as they appear (Cheema *et al.*, 124; Gangolly *et al.*, 500; Sattar, *Punjab Fr. J.*, 1946, **10,** 56; Narasimhan, *Curr. Sci.*, 1954, **23,** 297; 1959, **28,** 254; Singh, ibid., 1955, **24,** 168; Singh, 333–34).

Black tip or necrosis is a disease of the fruits often noticed in trees growing in the vicinity of brick kilns. Affected fruits show black spots at the distal end and fall down before reaching maturity. Different types show varying degrees of damage. The disease is attributed to the presence of poisonous ingredients in the fumes from brick kilns. It has been recommended that new orchards should not be planted within a mile of brick kilns and kilns near established orchards should not be operated during the fruiting season (Gangolly *et al.*, 501–02; Gandhi, loc. cit.; Sen, *Indian J. agric. Sci.*, 1943, **13,** 300; Pal *et al.*, *Proc. Indian Sci. Congr.*, 1937, pt III, 270; Ranjan & Jha, *Proc. Indian Acad. Sci.*, 1940, **11B,** 267; Das Gupta *et al.*, *Curr. Sci.*, 1950, **19,** 153; Singh, 271).

Among other diseases of mango mention may be made of fruit rot caused by *Aspergillus niger* van Tiegh., sooty mould caused by *Capnodium ramosum* Cooke and soft rot caused by *Bacterium carotovorus*. Parasitic fungi causing damage to stems, branches and leaves include: *Fomes conchatus* (Pers.) Gillet (white sap and heart spongy rot), *Ganoderma applanatum* (Pers.) Pat. (white rot), *Hexagonia discopoda* Pat. & Har. (white sap and heart rot), *Pestalotia mangiferae* P. Henn. (grey blight), *Phyllosticta mortoni* Fair. and *Physalospora rhodina* (Berk. & Curtis) Cooke (leaf blight), *Polyporus gilvus* Schwein. (white pocket rot), *Polystictus persooni* Fr. (white spongy rot), *Schizophyllum alneum* (L.) Schroet. (sap rot) and *Rhinocladium corticolum* Mass. (black bark). Red-rust, caused by *Cephaleuros mycoidea* G. Karst., has also been recorded in Uttar Pradesh, Bihar and Mysore (Verma & Kamal, *Curr. Sci.*, 1951, **20,** 68; Patel & Padhye, *Indian Phytopath.*, 1948, **1,** 127; Patel *et al.*, *Cur. Sci.*, 1948, **17,** 189; *Indian J. agric. Sci.*, 1950, **20,** 125; Singh, 282).

Two or three species of *Loranthus* commonly infest mango trees and cause considerable damage, sometimes killing entire branches. The seeds of the parasite are dispersed by birds. Removal of the parasite by cutting off infested portions with a hand saw and painting the wound with tar is the only method of control (Cheema *et al.*, 123–24; Singh, 335, 343).

Pests · Jassid hopper (*Idiocerus* spp.) is the most serious pest of mango blossoms all over India. Three species of hoppers, viz. *I. atkinsonii* Leth., *I. niveosparsus* Leth. and *I. clypealis* Leth., are known. The first is found mainly on the trunk and branches, while the other two are common on leaves and panicles. Of these, *I. clypealis* is the smallest and the most troublesome in Konkan and Karnatak. Nymphs and adults suck the sap of flowers and young fruits drop prematurely; they also secrete a sticky substance on which black sooty moulds, *Dimerosporium mangiferum* Sacc. syn. *Capnodium mangiferum* Cooke & Br. and *C. ramosum* Cooke develop covering the entire foliage and inflorescence. Spraying with crude oil emulsion, fish oil soap, fish oil rosin soap and tobacco decoction have been tried as control measures. Repeated dusting with sulphur at fortnight intervals commencing with the emergence of inflorescence has proved effective. Spraying with DDT is effective, but it is not advisable to use it alone as it favours the appearance of mites by killing its predators. Dusting with DDT and sulphur is therefore recommended. In the moist climate of West Bengal, spraying with Pestox-III in 4% concentration has proved beneficial [Ramakrishna Ayyar, 283–85; Hayes, 152; Cheema *et al.*, 118–19; Singh, 293–95; Uppal & Wagle, *Indian Fmg*, 1944, **5,** 401; Usman, *Mysore agric. J.*, 1951, **26,** 64; Sodhi & Batra, *Indian Fmg*, 1950, **11,** 158; Latif & Qayyum, *Punjab Fr. J.*, 1950, **14**(49), 6; Gandhi, loc. cit.; De & Dutta, *Indian J. Hort.*, 1955, **12,** 165].

The grub of the mango stem borer (*Batocera rufomaculata* De Geer) tunnels into the bark and feeds on live inner tissue. The borer may be killed by inserting a rod or wire into the tunnel or by syringing a mixture of chloroform and creosote and plugging the hole with wet clay (Ramakrishna Ayyar, 286–87; Naik, 1958, 59; Singh, 316).

The more serious leaf eating and shoot boring caterpillars of mango are *Parasa lepida* G., *Chlumetia transversa* Wlk. and *Orthaga exvinacea* M. They can be controlled by spraying DDT water

suspension (0.2–0.3%) prepared from Guesarol 550 wettable powder and wettable sulphur. Treatment with BHC is also said to be effective (Ramakrishna Ayyar, 288–90; Gandhi, loc. cit.; Naik, 1958, 59).

Fruit flies belonging to *Dacus ferrugineus* Febr., *D. zonatus* Saund. and a few other species attack mango fruits. The flies lay eggs under the rind of matured fruits which develop into white wriggling maggots. The only method of control is to destroy the affected fruits. There are five or six broods of the insect during the ripening season and complete destruction of the first brood is important. Raking of soil around the tree helps in destroying pupae. Poisoned baits containing sugar, lead arsenate and water are recommended to attract and kill flies before they lay eggs (Rahman, *Punjab Fr. J.*, 1946, **10,** 52; Parsons, *Trop. Agriculturist*, 1931, **76,** 199; Hayes, 154–55; Naik, 187).

Stone weevils, *Cryptorrhynchus gravis* Fabr. and *C. mangiferae* Fabr., affect fruits of some varieties; the former is found in eastern Bengal and the latter, in S. India. The weevils lay eggs in the young fruit and grubs find their way into the seed, passing the remainder of their lives inside the stone, changing into pupae and finally into weevils. When the fruit is ripe, they burrow their way out and spoil the pulp adjacent to the stone. There is no external sign of injury to the fruit. The *Bangalora* (*Totapuri*) of South India is the most susceptible to this pest. As a control measure, affected stones are burned to destroy the weevil (Hayes, 156–57; Gandhi, loc. cit.; Singh, 319).

Scale insects, like *Aspidiotus destructor* S., *Leucaspis indica* and *Pulvinaria psidii* M., are known to attack tender branches and leaves and suck the sap. Hard scales may be killed by spraying rosin compounds; soft scales and mealy bugs are checked by washes of crude oil emulsion, fish oil soap, etc. Spraying Folidol is also effective (Ramakrishna Ayyar, 294–96; Naik, 1958, 59).

Mealy bugs, *Phenacoccus mangiferae* G. and *Drosicha stebbingi* Green, sometimes infest mango trees covering fruits, tender leaves and shoots. Banding trees with greased bands and trapping nymphs as they crawl up the trunks have proved effective in controlling the bugs in Uttar Pradesh (Rahman & Latif, *Bull. ent. Res.*, 1944, **35,** 197; Singh, 298).

Red ants (*Oecophylla smaragdina* Fabr.) though not directly injurious, act as distributing agents of noxious scales and mealy bugs from tree to tree. They are destroyed by dusting with Gammexane and sulphur (Ramakrishna Ayyar, 296; Gandhi, loc. cit.; Naik, 189).

Harvest and Yield

Grafted mango trees begin to bear fruit from the fourth year onwards. The yield is low to start with, 10–15 fruits per tree, rising to 50–75 fruits in the sixth year and to 300–500 in its tenth year. Trees which are 20–40 years in age, yield a crop of 1,000–3,000 fruits in 'on' years; the yield usually declines after forty years. In the uncultivated orchards of Konkan, yield of *Alphonso* from trees 20–30 years in age averages to 200–300 fruits per tree; in well cared orchards, the yield is as high as 5,000 fruits. For varieties like *Langra*, *Dusehri*, *Pairi*, *Neelum*, *Bangalora*, *Suvarnarekha* and *Baneshan*, the yields vary from 800–3,000 fruits per tree per 'on' year. The yield from shy bearing types, like *Jehangir*, does not exceed 250 fruits (Naik, 182; Gandhi, loc. cit.; Gangolly *et al.*, 483).

Mango is harvested in Konkan from April to May, whereas in the Deccan and South Gujarat, the harvest begins in May and continues till June. In South India, the harvest season opens with *Olour* mangoes in February or March and is at its height in April and May. In coastal Andhra, the harvest lasts from April to July and in Rayalaseema and Mysore, it extends over a period of four months, from May to August. In Bihar, Uttar Pradesh and other parts of North India, the harvest season lasts from early June to late August (Gandhi, loc. cit.; *Marketing of Mangoes in India, Agric. Marketing Ser.*, No. 77, 1958, 19–22).

The mango takes about five months from the time of flowering to mature and ripen. Fruits are plucked from the tree when they are yet hard and green; if left on the tree till ripe, they are likely to be eaten by birds. It is generally believed that when a few semi-ripe fruits begin to fall naturally from the tree, the crop is mature enough for picking. Fruits are picked in several instalments at frequent intervals. A bamboo pole harvester is often used to pick mango fruits without bruising the skin. This appliance varies in details from place to place (Gandhi, loc. cit.; *Marketing of Mangoes in India*, 1958, 66–67).

Ripening—Mangoes undergo a process of artificial ripening before selling. Some amount of ripening takes place during transport when sent to distant markets. Usually retail merchants ripen the fruits in

closed, but well ventilated, store houses. The fruits are placed in single layers over paddy straw or wheat bhusa, spread three to four inches thick on the floor of the house. Sometimes two or three layers are built up, one above the other separated by *c.* 2 in. of straw. Fruits thus kept turn yellow and become slightly soft within a week's time. Ripening of fruits at 67–70°F. under temperature control is reported to improve the percentage of total soluble solids, reduce acidity and ensure better ascorbic acid retention (*Marketing of Mangoes in India*, 1958, 67–68 ; Singh & Mathur, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1952–53, **2,** 14).

Marketing—The crop is sold in advance by growers to commission agents or contractors. The latter in fixing the price, take into consideration the risk of failure or damage to crops by adverse weather conditions. In recent years, a number of growers' co-operative associations have been started and transport and marketing are organized by the associations (*Marketing of Mangoes in India*, 1958, 125).

Packing and grading—Mangoes are packed in baskets, boxes or crates for transport to distant markets ; if the markets are close, they may be sent loose in bullock carts. Cylindrical or semi-spherical bamboo baskets, holding 50–100 fruits are generally used for packing mangoes all over India. For packing superior varieties, wooden crates, 60 cm. × 30 cm. × 30 cm., holding about 100 fruits are used. The fruits are packed between layers of rice straw or any kind of soft dry grass. For overseas export of *Alphonso*, under cold storage, crates measuring 45 cm. × 25 cm. × 11.2 cm. each and holding one dozen fruits in a single layer, are convenient : individual fruits are wrapped in tissue paper and held in position by wood wool packing (Gandhi, loc. cit. ; *Marketing of Mangoes in India*, 1958, 68–74 ; Singh, 355).

The majority of growers pack large sized, attractive fruits on the top and small, diseased or damaged fruits at the bottom of the basket. Efforts have been made in Bombay, Bihar, Madras and Uttar Pradesh, to grade and mark choice types, according to standard sizes and quality prescribed under the Agricultural Produce (Marking & Grading) Act, 1937. The number of grades varies. Often they are sorted according to size and stage of maturity as judged by the eye ; a few growers sort fruits by passing them through circular holes of varying diameters. Fruits intended for export are selected : grade designations and definition of quality have been prescribed for choice types, like *Alphonso*, *Bangalora* and *Dusehri* (*Marketing of Mangoes in India*, 1958, 75–79, appx. XXIX a–c).

Most dessert varieties of mango do not keep for more than a week after ripening. *Alphonso* keeps in wholesome condition for 2 weeks and *Bangalora* keeps for 4 weeks. Other well-known good keepers are *Neelum* and *Rumani* from Madras, *Baneshan* from Andhra and *Dusehri* from U.P. (Gandhi, loc. cit.).

Storage—Cold storage facilities are available in important consuming centres for preserving mangoes for short periods. Green mature fruits have good storage life ; fruits ripened on the tree are unsuitable for storage. Studies on refrigerated preservation of 28 types of mangoes from different States have shown that only certain types are suitable for storage. Bombay *Alphonso* keeps well for 6–7 weeks at 45°F. and 4 weeks at 52°F. The storage life of some Mysore-grown mangoes (green mature) are as follows (opt. R. H. 85–90%): seedling mangoes, 42 days (42–50°F.) ; *Pairi* (*Raspuri*), 42 days (42–45°F.) ; and *Alphonso* (*Badami*), 28 days (47–50°F.) (*Marketing of Mangoes in India*, 1958, 85–89 ; Cheema *et al.*, *Indian J. agric. Sci.*, 1950, **20,** 259 ; Mathur *et al.*, ibid., 1953, **23,** 65).

During storage, a large number of fungi infect fruits and cause sometimes serious losses. Of these the common one is *Colletotrichum gloeosporioides* which causes a lateral rot of fruits. The disease appears in the form of profuse anthracnose spottings at storage temperatures of 47–50°F. and 52–55°F., rendering the fruits unmarketable. Spraying with Bordeaux mixture as recommended for anthracnose can considerably reduce damage. Disinfection of fruits before storage with various agents have not proved effective (Singh, 286).

Composition and Uses

The mango fruit is one of the most highly prized dessert fruits of the tropics. It has a rich, luscious, aromatic flavour and a delicious taste in which sweetness and acidity are delightfully blended. Young and unripe fruits are usually acidic and used in pickles, chutney, *amchur* and culinary preparations. Ripe fruits are preserved by canning or used in the manufacture of juice and squash, jams and jellies, preserves (*murraba*) and *am papar*.

Analysis of the flesh of Indian mangoes gave the following average values: *green mango*—moisture, 90.0 ; protein, 0.7 ; fat, 0.1 ; carbohydrates, 8.8 ; mineral matter, 0.4 ; calcium, 0.01 ; and phosphorus, 0.02% ; iron, 4.5 mg./100 g. ; carotene (as vitamin A),

150 i.u.: riboflavin, 30 μg.: and ascorbic acid, 3 mg./100 g.; *ripe mango*—moisture, 86.1; protein, 0.6; fat, 0.1; carbohydrates, 11.8; fibre, 1.1; mineral matter, 0.3; calcium, 0.01; and phosphorus, 0.02%; iron, 0.3 mg./100 g.: carotene (as vitamin A), 4,800 i.u.; nicotinic acid, 0.3 mg.; riboflavin, 50 μg.: and ascorbic acid, 13 mg./100 g. The sugar and acid contents vary widely with variety and stage of maturity (Table 4). Table 5 gives *p*H, sugar and β-carotene contents of pulps of some varieties of ripe mango (*Hlth Bull.*, No. 23, 1951, 46; Cheema *et al.*, *Indian J. agric. Sci.*, 1950, **20**, 259).

Sucrose, glucose and fructose are the principal carbohydrates present in ripe mango; maltose is also present. Analyses of 22 varieties of ripe fruits from different States gave the following values: total sugars, 11.20–16.80; reducing sugars, 1.40–4.83; and non-reducing sugars, 8.19–13.81%; a sample of *Nilambri* mango contained 20.5% total sugars. Small amounts of cellulose, hemicelluloses and pectins are present. The green tender fruit is rich in starch; during ripening, the starch is hydrolysed into reducing sugars and a part of the latter is synthesized into sucrose. In the post-ripening stage sucrose decomposes into reducing sugars (Srivastava, *J. sci. industr. Res.*, 1953, **12B**, 363; Cheema *et al.*, loc. cit.; Nandi, *Sci. & Cult.*, 1957 58, **23**, 618; Leley *et al.*, *Indian J. agric. Sci.*, 1943, **13**, 291).

Unripe, fully developed mangoes of pickling varieties contain citric, malic, oxalic, succinic and two unidentified acids (probably di- or tri-basic acids); citric acid is the dominant constituent. As the fruit ripens, the acidity gradually decreases with a steep fall at the ripe stage. Analyses of 22 varieties of mangoes from different parts of India showed that the acid content (as malic acid) ranged from 0.67–3.66% in green fruits and 0.18–0.56% in ripe fruits (Cheema *et al.*, loc. cit.; Singh, 364; Giri *et al.*, *J.*

TABLE 4—SUGAR AND ACID CONTENTS OF GREEN AND RIPE FRUITS OF SOME MANGO VARIETIES*

Variety	Place of origin	Green			Ripe		
		Reducing sugars %	Non-reducing sugars %	Acidity† %	Reducing sugars %	Non-reducing sugars %	Acidity† %
Suvarnarekha	Bobbili	3.43	1.07	1.50	3.98	10.04	0.30
Pairi	Poona	1.35	0.91	2.75	2.12	10.15	0.40
Banganpalli	Alamanda	4.16	3.94	0.80	2.80	11.10	0.20
Langra	Sabour	3.39	2.58	0.67	2.36	13.81	0.22
Zardalu	Sabour	..	..	..	3.83	9.77	0.20
Fazri Zafrani	Saharanpur	2.31	2.04	1.63	2.48	9.37	0.56
Alphonso	Ratnagiri	1.41	1.13	2.54	3.23	9.68	0.18
Alphonso	Poona	1.18	0.98	2.54	1.82	11.32	0.27

* Cheema *et al.*, *Indian J. agric. Sci.*, 1950, **20**, 259.
† As malic acid.

TABLE 5—ANALYSIS OF PULPS OF SOME VARIETIES OF RIPE MANGO*

Variety	Moisture %	Glucose %	Fructose %	Sucrose %	β-Carotene μg./100 g.	*p*H
Badami (Alphonso)	80.68	3.10	4.83	8.51	5,616	4.01
Raspuri (Pairi)	82.06	2.34	3.84	9.62	3,861	3.99
Totapuri (Bangalora)	83.02	1.69	3.99	8.88	1,831	4.20
Neelum	81.10	2.21	4.78	6.67	2,081	4.04
Padiri	79.54	1.00	2.57	12.30	4,698	3.92
Safeda Lucknow	78.63	3.41	2.64	9.26	1,183	4.30
Safeda Malihabad	75.43	4.32	2.30	10.30	2,096	4.28
Dusehri	78.00	1.91	3.64	12.58	2,297	4.60

* Girdhari Lal *et al.*, *Food Sci.*, 1960, **9**, 121.

Indian Inst. Sci., 1953, **35A,** 93; Jain *et al.*, *Food Sci.*, 1959, **8,** 115; Wahhab & Khan, *Pakist. J. sci. Res.*, 1954, **6,** 124).

The amino acids present in the non-protein nitrogen fraction of the mango fruit are: aspartic acid, glutamic acid, alanine, glycine, methionine, leucines and possibly cystine and γ-amino-butyric acid (Govindarajan & Sreenivasaya, *Curr. Sci.*, 1950, **19,** 234).

Ripe fruits constitute a rich source of vitamin A; some varieties contain fairly good amounts of vitamin C also. The vitamin A content varies widely with variety and stage of maturity; the following are the values recorded for ripe fruits of some important varieties: *Alphonso* (Bombay), 101.1; *Safeda* (Bombay), 16.6; *Totapuri* (Bombay), 17.8; *Malda* (Bombay), 7.2; *Langra* (Varanasi), 32.2; *Langra* (Calcutta), 24.0; *Dusehri* (Lucknow), 51.5; *Fazli* (Calcutta), 45.3; *Chausa*, 16.0; *Sehroli*, 179.5; *Desi* (Delhi), 10.6; *Badami* (Mysore), 100.9; *Raspuri* (Mysore), 78.8; *Neelum* (Mysore), 39.4; *Mulgoa* (Mysore), 28.1; *Rumani* (Chittoor), 17.1; and *Kalepad* (Chittoor), 55.1 i.u./g.; the highest value (259.4 i.u./g.) has been recorded for *Mankurad* mango from Goa (Sadana & Ahmad, *J. sci. industr. Res.*, 1949, **8B,** 35; *Indian J. med. Res.*, 1946, **34,** 69; Siddappa & Bhatia, *J. sci. industr. Res.*, 1956, **15C,** 118; *Bull. cent. Fd technol. Res. Inst., Mysore*, 1955–56, **5,** 236; *Rep. Dep. Nutr. Govt. Bombay*, 1957, 26).

Analysis of mangoes (from Bombay) gave the following ranges of vitamin (other than vitamin A) values: thiamine, 40.82–130.50 μg.; riboflavin, 69.39–198.20 μg.; niacin, 1.38–6.27 mg.; and ascorbic acid, 4.38–39.96 mg./100 g. The ascorbic acid content of mangoes from different parts of India varied from 13.2–80.3 mg./100 g. Ripe *Langra* is exceptionally rich in ascorbic acid (176 mg./100 g.); the acid is concentrated in the peel and the flesh adhering to it, and it is highest at the green mature stage. Mango is a poor source of folic acid (*Rep. Dep. Nutr. Govt. Bombay*, 1957, 26; Singh, 365; Nandi, loc. cit.; Wahhab & Khan, loc. cit.; Spencer *et al.*, *Plant Physiol.*, 1956, **31,** 79; Asenjo *et al.*, *Food Res.*, 1950, **15,** 326).

β-Carotene and xanthophyll are the principal pigments present in ripe mango; neo-β-carotene U and neo-β-carotene B are present in small amounts; neo-xanthophyll is present only in a few varieties. Analyses of 9 varieties of ripe mango showed that the total pigment content varied from 10.0 to 164.9 μg./g.; the maximum value was found in *Sehroli*, which contained: xanthophyll, 42.1; β-carotene, 96.3; neo-β-carotene U, 7.3; and neo-β-carotene B, 19.2 μg./g. The concentration of carotenoid pigments increases during ripening; the rate of increase of β-carotene is greater than that of others and an average-sized mango may synthesize as much as 1,200 μg. of β-carotene in a day. The rate of increase during ripening is influenced by temperature, although the maximum values are not appreciably altered. Exposure of mature fruits to ultraviolet light appears to increase the total carotenoid content (including the max. value) (Sadana & Ahmad, *J. sci. industr. Res.*, 1949, **8B,** 35; *Indian J. med. Res.*, 1949, **37,** 193; Chaudhary, *J. Sci. Fd Agric.*, 1950, **1,** 173).

Catalase and peroxidase are the principal enzymes of mango; their activity is maximum at full development, *c.* 115 days after fruit setting (Banerjee & Kar, *Curr. Sci.*, 1941, **10,** 289).

The fruit is a rich source of potassium. Analysis of pulp ash (ash content, 0.53%) gave the following values: potassium (K_2O), 47.37; calcium (CaO), 6.38; magnesium (MgO), 1.62; phosphorus (P_2O_5), 6.49; sulphur (SO_3), 3.67; and chlorine, 3.88%. Copper (1.9 μg./g.) and iodine (16 μg./kg.) are present in the ripe fruit. Phytin is also present (Winton & Winton, II, 732; Bagchi & Chowdhury, *Ann. Biochem.*, 1949, **9,** 107; Patnaik, *Indian J. med. Res.*, 1934, **22,** 249).

Ripe mango fruit is considered invigorating, refreshing and fattening. The juice, along with aromatics, is recommended as a restorative tonic. It contains vitamins A and C and is useful in heat apoplexy.

Leaves—Tender mango leaves (mango tops) are consumed as vegetable in Java and Philippines. They are a good source of ascorbic acid. Analysis of mango tops gave the following values: moisture, 78.2; protein, 3.0; fat, 0.4; total carbohydrates, 16.5; fibre, 1.6; and ash, 1.9%; calcium, 29 mg.; phosphorus, 72 mg.; and iron, 6.2 mg./100 g.; carotene (as vitamin A), 1,490 i.u.; thiamine, 0.04 mg.; riboflavin, 0.06 mg.; niacin, 2.2 mg.; and ascorbic acid, 53 mg./100 g. Mature mango leaves are used as cattle fodder in times of scarcity. They contain (dry basis): crude protein, 7.8; ether extr., 3.8; N-free extr., 54.0; fibre, 21.1; ash, 13.3; phosphorus (P_2O_5), 0.38; and calcium (CaO), 2.93%. The leaves contain the glucoside mangiferine ($C_{19}H_{18}O_{11}$, m.p. 280–81° decomp.); cows feeding on mango leaves excrete in the urine, euxanthic acid ($C_{19}H_{16}O_{10}$, m.p. 162°) which is yellow in colour and is derived from the glucoside.

Prolonged feeding of leaves may result in the death of the animals. The leaves, when crushed, emit an aroma which is a blend of turpentiny and fruity odours. Distillation of leaves gave 0.1% of a viscous, dark red, volatile oil (sp. gr.$^{32°}$, 1.002 ; $n^{32°}$, 1.505), soluble with turbidity in 1.5 vol. of 80% alcohol [Burkill, II, 1405 ; *Handb. Inst. Nutr. Philipp.*, No. 1, 1957, 24 ; Patel & Patel, *Indian J. agric. Sci.*, 1957, **27,** 307 ; Mayer & Cook, 246–47 ; *Chem. Abstr.*, 1959, **53,** 21915 ; Krishna & Badhwar, *J. sci. industr. Res.*, 1948, **7**(10), suppl., 141 ; Dhingra, 45].

The ash of burnt leaves is a household remedy for burns and scalds. The leaves are masticated to give tone to the gums. Fumes from the burning leaves are inhaled for relief from hiccups and affections of the throat (Kirt. & Basu, I, 653–54 ; Dastur, Medicinal Plants, 152–53).

Blossoms—The air-dried blossoms contain 15% tannin (as gallotannic acid). Gallic acid can be extracted in 9% yield by treating aqueous extracts of blossoms with *Aspergillus niger.* Two light yellow, crystalline substances (m.p. 244° and 266°), which are probably flavones, have been isolated from alcoholic extracts of blossoms (Bose & Siddiqui, *J. sci. industr. Res.*, 1948, **7B,** 100).

The fragrant flowers were formerly used in preparing an otto, *Am Attar.* On steam-distillation, the flowers yield 0.04% of a pale brownish essential oil having the following characteristics: $d^{33°}$, 0.779 ; $n_D^{33°}$, 1.4834 ; $[\alpha]_D^{33°}$, +9° ; acid val., 3.9 ; and ester val., 27.6. It contains 2-octene, *α*- and *β*-pinene, *α*-phellandrene, limonene, dipentene, nerol, geraniol, neryl acetate, citronellal, a sesquiterpene alcohol named mangiferol ($C_{15}H_{26}O$) and a sesquiterpene ketone ($C_{15}H_{22}O$) (Krishna & Badhwar, loc. cit. ; Baslas, *Perfum. essent. Oil Rec.*, 1961, **52,** 156).

Dried mango flowers are astringent. They are given for diarrhoea, chronic dysentery, catarrh of the bladder and gleet (Kirt. & Basu, I, 653–54 ; Dastur, Medicinal Plants, 152–53).

Bark—The bark of the mango tree contains tannin (16–20%) and may be used for tanning purposes ; it contains resinous matter. The bark yields a colouring matter which produces beautiful, though light, yellow shades on cotton, silk and wool ; in conjunction with turmeric and lime, the bark dyes cotton a bright rose-pink. Mangiferine has been isolated from the bark. The bark is astringent ; it is used in diphtheria and rheumatism ; it is believed to possess a tonic action on the mucous membrane (Howes, 1953, 281 ; *Chem. Abstr.*, 1959, **53,** 22264).

Gum—The stem exudes a gum resin which is sold in Indian bazaars and used as a substitute for gum arabic. It has a dull fracture and a reddish brown colour. It is partly soluble in water. Analysis of mango gum gave the following values: moisture, 4 ; resin, 79 ; gum, 15 ; and ash, 2% ; methoxyl index, 18. Furfurol is obtained in 1.8% yield by distilling the gum with dil. hydrochloric acid. The gum is used in dressings for cracked feet and for scabies. It is also considered anti-syphilitic (Howes, 1949, 58 ; Krishna & Badhwar, loc. cit. ; Janot & Gonnard, *Bull. Sci. pharm.*, 1938, **45,** 396 ; Mathur & Banerjee, *J. sci. industr. Res.*, 1956, **15A,** 571).

Chep—A thin fluid with vesicating properties, known as *chep*, exudes when the fruit is detached from the stem. It has a turpentine-like odour when fresh, but soon dries to a straw-coloured, translucent, semi-solid odourless mass. A resin, mangiferen ($C_{21}H_{34}O$), a resinous acid, mangiferic acid ($C_{40}H_{60}O_4$) and a resinol, mangiferol, $(C_{21}H_{36}O_2)_x$, all of which bear a close relationship to the abietic acid series of resins, have been isolated from the ether-soluble fraction of *chep.* The water-soluble fraction contains gum but no tannic or gallic acid (Vasistha & Siddiqui, *J. Indian chem. Soc.*, 1938, **15,** 110).

The extracts of leaves, bark and stems, and unripe fruits exhibit moderate anti-bacterial activity against *Micrococcus pyogenes* var. *aureus.* The occurrence of antifungal micro-organisms in ripe mango has been reported (Bushnell *et al.*, *Pacif. Sci.*, 1950, **4,** 167 ; Majumdar & Bose, *J. sci. industr. Res.*, 1955, **14C,** 126).

Seed kernel—The seed kernels have an astringent taste and contain: protein, 9.5 ; fat, 10.7 ; starch, 72.80 ; sugar, 1.07 ; tannin, 0.11 ; and ash, 3.66% : silica (SiO_2), 0.41 ; iron (Fe_2O_3), 0.03 ; calcium (CaO), 0.23 ; magnesium (MgO), 0.34 ; phosphorus (P_2O_5), 0.66 ; sodium (Na_2O), 0.28 ; potassium (K_2O), 1.31 ; sulphur (SO_4), 0.23 ; and carbonate (CO_3), 0.09%. The kernels are free from any toxic principles. The amino acids of the kernel proteins are: cystine, aspartic acid, glutamic acid, glycine, threonine, alanine, tyrosine, histidine, arginine, lysine, proline, valine, methionine(?), leucines and phenylalanine (Dhingra *et al.*, *Proc. Oil Technol. Ass. India*, 1948, **3,** 39 ; Ramayya, *Bull. Dep. Agric., Madhya Pradesh*, No. 38, 1952 ; Das & Biswas, *Sci. & Cult.*, 1953–54, **19,** 158).

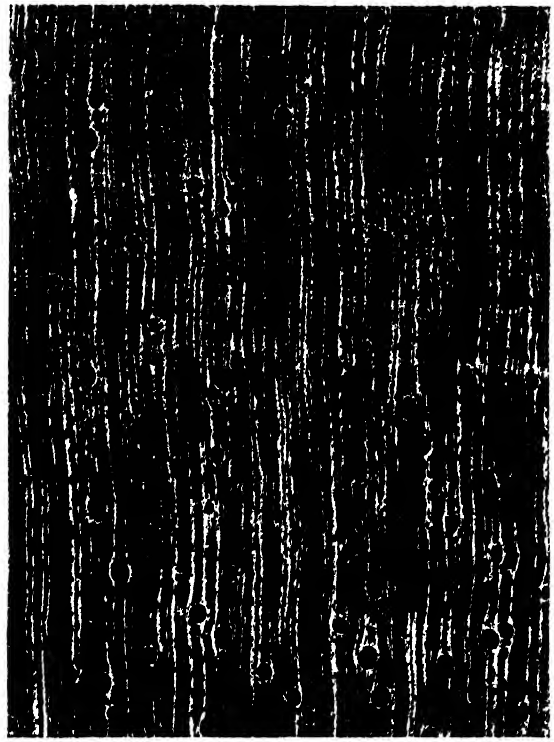
The seed kernels on extraction with solvents yield 6–12% of a solid edible fat (Mango Seed Oil or

Mango Butter), resembling cocoa butter and tallow. The fat is greyish white with a mild odour. It has the following characteristics: sp. gr.$^{30°}$, 0.9139; $n^{40°}$, 1.4604; acid val., 0.28; sap. val., 194.8; iod. val., 39.2; R.M. val., 0.12; Hehner val., 95.7; and unsapon. matter, 2.87%. The fatty acid composition of the seed fat is as follows: myristic, 0.69; palmitic, 8.83; stearic, 33.96; arachidic, 6.74; and oleic, 49.78%: it contains fully saturated glycerides, 14.2; mono-oleoglycerides, 24.2; di-oleoglycerides, 60.8; and tri-unsaturated glycerides, 0.8% (Pathak *et al.*, *J. Indian chem. Soc.*, 1946, **23,** 407; Ramayya, loc. cit.).

The kernels are used as human food in certain parts of India in times of scarcity. They are sometimes roasted or boiled for eating; they are also converted into flour after soaking in water and eliminating the astringent principles. The flour does not keep well and should be consumed fresh. As compared to cereals, mango kernel flour contains more fat and calcium; the protein content is less than that of wheat, maize and barley (Ramayya, loc. cit.; Wilkins, *Indian Fmg*, 1942, **3,** 636).

The dried kernel (digestible protein, 6.1; total digestible nutrients, 70.0; starch equivalent, 67.5 lb./100 lb.) is used as feed for cattle and poultry. Bullocks take 2–3 weeks to acquire a taste for the material; feeding trials have shown positive balances with regard to nitrogen, calcium and phosphorus. The kernel may be used as such or after composting as manure. The kernel powder is used as anthelmintic and also as astringent in bleeding piles (Ramayya, loc. cit.; Kehar & Chanda, *Curr. Sci.*, 1946, **15,** 48; Ranjan *et al.*, *Proc. Indian Acad. Sci.*, 1951, **33B,** 288).

Timber—Mango wood (sp. gr., 0.59; wt., 38–50 lb./cu.ft.) is grey or greenish brown, moderately strong, hard, straight or occasionally curly grained and coarse-textured. It is not durable when exposed (grave yard test shows a life of 2–3 years) but is quite durable under water. It is easy to season; the common practice in the west coast is to season the timber as planks in salt water. It kiln-seasons without degrade. The wood can be sawn and worked without difficulty and finished to a fine surface. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 95; strength as a beam, 75; stiffness as a beam, 80; suitability as a post, 75; shock-resisting ability, 100; retention of shape, 95; shear, 105; and hardness, 90 (Pearson & Brown, I, 315–17; Trotter, 1944, 133; Krishnamurti Naidu, 85; Purushotham *et al.*, *Indian For.*, 1953, **79,** 49; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** 54, Sheet No. 13).



F.R.I., Dehra Dun. Photo: S. S. Ghosh

FIG. 92. MANGIFERA INDICA—TRANSVERSE SECTION OF WOOD (×10)

The timber is used for furniture, floor and ceiling boards, window frames, tea chests, packing boxes, match boxes and splints, brush backs, oar blades and agricultural implements. In Madras and west coast, it is valued for dugouts and boats. It is used also for plywood and shoe heels. After preservative treatment, it can be used as a substitute for teak for beams, rafters, trusses and door and window leaves. A hard charcoal of high calorific value is obtained from mango wood [Gamble, 212; Trotter, 1944, 134; Rodger, 54, 133; Krishnamurti Naidu, 85; *J. Timb. Dryers' & Pres. Ass. India*, 1956, **2**(1), 22].

Mango Fruit Products

Dried slices—Immature mangoes are cut into slices, mixed with salt (6–8%) and dried in the sun. The dried product is packed in wooden casks and used in the preparation of chutney and pickles (*Marketing of Mangoes in India*, 1958, 134).

TABLE 6—COMPOSITION OF COMMERCIAL MANGO CHUTNEY*

	Total solids†	Total sugars	Acidity (as citric acid)	Total ash	Alkalinity of ash (ml. N acid/100 ml.)	Salt (NaCl)
	%	%	%	%		%
Sweet chutney	71.1	67.7	1.02	1.63	3.51	1.05
Hot chutney	67.8	65.6	0.87	1.73	1.00	1.20
Major Grey chutney	67.6	64.5	1.02	1.87	..	1.42
Col. Skinners chutney	64.5	62.1	1.65	4.65	..	3.83
Bengal club chutney	64.0	62.0	1.62	4.59	..	3.80

* Siddappa & Swamy, *Food Sci.*, 1959, **8**, 218.
† Refractometer solids.

A popular method of preserving unripe mango is to cut the peeled material into thin slices and drying in the sun; slices may be seasoned with turmeric powder before drying. Known as *Amchur,* the dried material is used as such or after grinding into powder. The powder keeps well for about 3 years if packed in air-tight containers. *Amchur* is used as a souring agent for soups, chutneys and vegetables. Analysis of a commercial sample gave the following values: moisture, 14.7; total acidity (as tartaric acid), 15.2; glucose, 3.0; and ash, 5.4% [Roy & Singh, *Indian Fd Packer*, 1952, **6**(4), 13; *Marketing of Mangoes in India*, 1958, 134; Bountra & Pandya, *Proc. Indian Acad. Sci.*, 1936, **4A**, 452].

Mango chutney—Immature fruits of seedling varieties are preferred for the preparation of chutney. Peeled slices are softened by heating with a small amount of water. Sugar, salt, red chilli powder, ginger and other spices (cardamom, cinnamon, cumin, etc.) are added and the mixture cooked over slow fire till fairly thick. Vinegar is then added and cooking continued till the desired consistency is attained. In some preparations, spices are not mixed with mango slices, but tied loosely in a muslin cloth and immersed in the mass during cooking. Raisins and other dry fruits are sometimes added.

Six brands of chutney are available in the trade viz. Sweet Chutney, Hot Chutney, Major Grey Chutney, Col. Skinners Chutney, Kashmir Chutney and Bengal Club Chutney. Table 6 gives the composition of the different brands. Chutney manufacturers in Delhi and northern India produce a product which is more akin to sweet pickle with practically no acid. Agmark grade designations have been specified for chutney and considerable quantities of the product are exported (*Rep. Chutney Industry in India*, Minist. Food & Agric., Govt. of India, 1957, 29–30; Girdhari Lal *et al.*, 206; *Marketing of Mangoes in India*, 1958, 133; Siddappa & Swamy, *Food Sci.*, 1959, **8**, 218).

Mango pickle (*Achar*)—The recipes for mango pickles vary widely in different parts of the country, but the ingredients are the same and include: slices of unripe mango, mustard oil, fenugreek, turmeric, fennel, powdered red chilli, salt and pepper. Unripe but fully developed tart mangoes of seedling varieties are used (*Marketing of Mangoes in India*, 1958, 133; Girdhari Lal *et al.*, 228).

Canned mango—*Safeda*, *Sehroli*, *Dusehri*, *Alphonso*, *Pairi*, *Banganpalli*, *Neelum* and *Mulgoa* are preferred for canning. Firm ripe fruits are selected, washed, peeled and the flesh cut into longitudinal slices of almost equal size. The slices are placed in brine (2%) to prevent browning and canned in hot sugar syrup (40° Brix) containing 0.3-0.5% citric acid. Mango pulp obtained by squeezing out the juice from ripe fruits are canned in the same way as slices. Trimmings are used in the preparation of jams and squashes (Girdhari Lal *et al.*, 66; *Marketing of Mangoes in India*, 1958, 132).

Canned mangoes are a good source of β-carotene and ascorbic acid. The vitamins are well retained in canned slices; the pulp, however, suffers loss of ascorbic acid (Siddappa & Bhatia, *J. sci. industr. Res.*, 1956, **15C**, 118; *Indian J. Hort.*, 1955, **12**, 129; *Bull. cent. Fd technol. Res. Inst., Mysore*, 1955–56, **5**, 236).

Mango leather (*Am-papar*)—Mango pulp dried in the form of sheets or slabs is commonly called mango leather or mango bread (*Am-papar*). Ripe fruits of sucking types are utilized for this purpose.

The juice is squeezed out, strained through cloth and spread in thin layers over mat, slate or wooden plank previously smeared with mustard oil and dried in the sun. The sheets are removed and pressed, one over the other, into slabs ¼–½ in. thick. The product is exposed to sulphur fumes before packing. *Ampapar* is produced on a cottage scale in all mango-growing regions (*Marketing of Mangoes in India*, 1958, 134 ; *Brochure on Home-Scale Food Preparation Series*, Cent. Fd technol. Res. Inst., Mysore, 1959, No. 23).

An improved process for the preparation of *ampapar* has been patented. It involves steeping of mango flesh in sugar solution (containing citric acid, if necessary), followed by steaming for 15–30 min., addition of sulphur dioxide and keeping overnight. The mass is strained, passed through a pulping machine and the pulp spread on trays and dried in the sun or in a cabinet drier at 140–45°F. Dried sheets are cut into pieces and pressed into slabs. The product obtained by dehydration in a cabinet drier is superior to the sun-dried product with regard to both colour and flavour. The carotene loss during drying amounts to 30–50%, while the loss of ascorbic acid is 92–98% [Siddappa & Bhatia, (to C.S.I.R.), *Indian Pat.* 49441, 1953 ; Das *et al.*, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1954–55, **4**, 157].

Another method for the preparation of mango leather consists in extracting the pulp from ripe mangoes, adding sugar to raise the Brix to 25–28° and concentrating to a paste in a double-drum drier. The paste is mixed with tamarind seed jellose and corn flour, spread into sheets and dried in an oven at 40–45° (Rao & Dang, *Res. & Ind.*, 1958, **3**, 208).

Juice powder—A process for the production of mango juice powder has been worked out at the Central Food Technological Research Institute, Mysore. It consists in concentrating the juice, blending with sugars, fruit acids, etc. and drying in a vacuum shelf drier. The dried material is powdered and packed in air-tight containers with or without in-package desiccants. The product is a rich source of vitamins and can be used in the preparation of ice-creams and infant and invalid foods. It can be reconstituted into juice and used as a beverage [Siddappa & Girdhari Lal (to C.S.I.R.), *Indian Pat.* 49590, 1953].

Blends of mango pulp and wheat flour may be processed into various forms—flakes, vermicelli, flour etc.—for use as breakfast food or as a thickener and flavouring agent for ice-creams and other food preparations (Girdhari Lal *et al.*, *Indian J. agric. Sci.*, 1956, **26**, 329 ; Girdhari Lal & Jain, *Res. & Ind.*, 1956, **1**, 229).

A preparation known as mango custard powder, is obtained from mango pulp mixed with skimmed milk powder, sugar, corn starch and other ingredients. The blend is dried to 1–1.5% moisture and ground to a granular powder. Analysis of a sample of mango custard powder gave the following values: moisture, 1.3 ; protein, 7.1 ; fat, 0.17 ; starch, 3.6 ; reducing sugars, 18.4 ; fibre, 1.5 ; and ash, 2.6% : iron, 6.6 mg. ; phosphorus, 204.0 mg. ; calcium, 238.0 mg. ; ascorbic acid, 32.8 mg. ; and β-carotene, 12,000 μg./100 g. : acidity (as citric acid), 1.18% [Siddappa & Rajam, *Indian Fd Packer*, 1958, **12**(5), 11 ; Korula *et al.*, *Ann. Biochem.*, 1960, **20**, 65].

Trade

Mango fruits—Large quantities of the fruit are consumed locally in producing areas. It is estimated that in 1956, out of the total production of 135.82 million md. of mango, 122 million md. were consumed either for table purposes (2.64 million md.) or for the production of pickles, chutneys and squashes. Losses in handling, storing and marketing amounted to 10% of the total production (*Marketing of Mangoes in India*, 1958, 25, 249).

There is considerable trade in mangoes between producing and consuming areas within each State

TABLE 7—EXPORT OF FRESH MANGOES
(Qty in cwt.)

Country	1957	1958	1959	1960
Kuwait	3,278	5,153	7,234	4,250
Bahrein Is.	2,938	3,422	4,394	3,349
Singapore	2,205	7,607	2,531	4,627
Malaya	2,004	8,500	3,240	1,786
Saudi Arabia	1,011	2,334	1,814	496
Aden	868	918	1,437	262
Trucial Oman	494	263	890	236
Iraq	140	65	17	..
United Kingdom	16	207	603	25
Others*	593	260	618	15,179
Total Qty (cwt.)	13,547	28,729	22,778	30,210
Total Val. (Rs.)	567,120	9,82,801	11,41,407	10,92,111

* Includes West and East Pakistan.

TABLE 8—MANGO PRODUCTS MANUFACTURED IN INDIA (1956)*

Product	Production (md.)	Mangoes utilized (md.)
Preserves	742	1,088
Chutney	22,938	45,876
Pickles	38,687	77,374
Pulp	1,877	3,754
Jams & Jellies	334	444
Squash, Crush & Syrup	104	52
Slices	4,798	9,596
Amchur	1,000,000	2,500,000
Total	1,069,480	2,638,184

**Marketing of Mangoes in India*, 1958, 248, Table 3.

TABLE 9—EXPORT OF MANGO PICKLES (Qty in cwt.)

Country	1957	1958	1959	1960
United Kingdom	9,770	7,738	4,680	6,822
Iraq	4,913	4,310	3,451	10,341
Saudi Arabia	810	441	645	575
U.S.A.	665	1,012	847	420
Singapore	440	377	209	277
Canada	406	257	146	213
Bahrein Is.	259	225	155	53
Kuwait	257	403	696	268
Hongkong	119	179	138	87
Others	1,181	960	972	1,773
Total Qty (cwt.)	18,820	15,902	11,939	20,829
Total Val. (Rs.)	17,40,448	15,06,824	11,25,392	19,80,709

and also between States. The major part of seedling mangoes is locally consumed, while selected qualities of grafted types are sent to markets in cities and towns; small quantities of choice varieties are exported to outside countries (Table 7). Important among the countries importing fresh mangoes from India are: Quwait, Bahrein, Saudi Arabia, Singapore and Malaya and U.K.

Mango products—Among the mango products produced on a commercial scale, mention may be made of chutney, pickles and *amchur*. Table 8 summarizes the available information on mango products manufactured in India. Chutneys and pickles are exported in fair quantities to various countries; the principal importer is U.K., followed by Iraq and in some years U.S.A. (Table 9). Mango products are graded according to standards of quality and composition prescribed under the Fruit Products Control Order (*Marketing of Mangoes in India*, 1958, 136 & appx XXXIII–XXXVI).

M. sylvatica Roxb.

D.E.P., V, 157; Fl. Br. Ind., II, 15; Mukherji, *Lloydia*, 1949, **12,** 94.

Assam—*Ban-am*; Nepal—*Chuchi-am*; Lepcha—*Kathorkung*.

A tall evergreen tree, up to 45 m. high, with a straight bole 15 m. long and 3.0 m. in girth, found commonly in Nepal, Sikkim and eastern Himalayas at 300–1,300 m., Assam, Khasi hills and Andaman Islands. Fruits ovate, elliptic, variable in size, 8–10 cm. long; flesh thin, slimy, fibreless; stone less furrowed than that of ordinary mango.

The unripe fruit is pleasantly aromatic and suitable for making tarts, pickles and jellies; the ripe fruit is inferior to mango (Mukherjee, *Sci. & Cult.*, 1949–50, **15,** 469; Fl. Assam, I, 336).

The wood of this species is white when freshly cut, ageing to light yellowish grey on exposure; heartwood lacking or scanty. It is light (sp. gr., 0.54; wt., 35 lb./cu. ft.), moderately hard straight- or somewhat broadly interlocked-grained and medium-textured. It saws with ease and machines to a smooth surface; it is easily worked by hand tools (Pearson & Brown, I, 318–19).

The wood is used for the same purposes as mango wood, and in the trade, it is commonly found mixed with the latter. It yields strong and fairly ornamental ply-board. It has been used to a limited extent for tea boxes in Assam, but has been given up as it is reported to react with the lead lining of boxes (Pearson & Brown, I, 319).

A number of other species of *Mangifera*, found in South-East Asia, are known to bear edible fruits. Some of them are: *M. altissima* Blanco; *M. caesia* Jack; *M. cochinchinensis* Pierre; *M. foetida* Lour.; *M. lagenifera* Griff.; *M. longipetiolata* King; *M. microphylla* Griff.; *M. oblongifolia* Hook. f.; *M. odorata* Griff.; *M. pentandra* Hook. f.; *M. quadrifida* Jack; *M. reba* Pierre; and *M. zeylanica* Hook. f. Some of them have been used as rootstock for mango in Malaysian countries (Burkill, II, 1401–07; Corner, I, 110–11; Mukherjee, *Sci. & Cult.*, 1949–50, **15,** 5, 469; Mukherji, *Lloydia*, 1949, **12,** 73; Fielden, *Tech. Commun., imp. agric. Bur.*, No. 7, 1936; Gunaratnam, *Trop. Agriculturist*, 1946, **102,** 23).

MANGLIETIA Blume (*Magnoliaceae*)

A small genus of trees distributed in South-East Asia. Three species are found in India.

M. insignis Blume

Fl. Br. Ind., I, 42; King, *Ann. R. bot. Gdn, Calcutta*, 1891, **3**, Pl. 55.

Nepal—*Seete soah*; Assam—*Pan-sopa, phul-sopa*; Khasi—*Dieng-rhi-basaw, dieng-rhi-balih.*

A lofty handsome tree, up to 27 m. in height and 2.1 m. in girth, found in eastern Himalayas and Assam up to an altitude of 3,000 m. Bark greyish white to reddish brown; leaves elliptic-lanceolate, coriaceous; flowers white or pink, fragrant; fruit purple when fresh.

The tree is propagated by seeds. It has been successfully grown by transplanting 9 or 17 months old seedlings from nursery beds in May or December. It yields a wood (wt., 32 lb./cu. ft.) which is yellowish white, even- or slightly interlocked-grained, fine-textured, soft and moderately strong. The wood takes long to season, but is easy to work and finish to a smooth satiny surface. It does not last long in contact with ground. The data for the comparative suitability of timber, expressed as percentages of the same properties of teak, are: wt., 75; strength as a beam, 70; stiffness as a beam, 80; suitability as a post, 75; shock-resisting ability, 90; retention of shape, 75; shear, 105; hardness, 60. The wood is suitable for light construction and indoor work, planking, packing cases, furniture, aircraft work, etc. Its cultivation in tea plantations in Assam has been recommended for fuel and timber purposes (Gamble, 10; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 54, Sheet No. 13; Fl. Assam, I, 16; Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 160).

M. hookeri G.E.S. Cubitt & W.W. Smith is a closely related tree found in Lakhimpur and Sibsagar. The wood is greenish brown, fine- and even-grained and durable. It is suitable for indoor work and furniture (Fl. Assam, I, 16).

Mango — *see* **Mangifera**

Mango Ginger — *see* **Curcuma**

Mangosteen — *see* **Garcinia**

Mangrove — *see* **Avicennia, Bruguiera, Ceriops, Rhizophora**

MANIHOT Mill. (*Euphorbiaceae*)

A large genus of tall herbs, shrubs or trees, mostly natives of Brazil and warmer parts of America as far north as Mexico. Three species have been introduced into India; *M. esculenta* (Cassava) is widely cultivated for its starchy tubers.

M. esculenta Crantz syn. *M. utilissima* Pohl; *M. aipi* Pohl; *M. dulcis* Pax; *M. palmata* Muell. Arg. Cassava, Manioc, Tapioca*

D.E.P., V, 157; C.P.; 766; Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 110, 206.

Tel.—*Karrapendalamu*; Tam.—*Maravalli kizhangu, ezhalai kizhangu*; Kan.—*Maragenasu*; Mal.—*Marachini kizhangu, kappa.*

Assam—*Simal alu.*

A low shrubby plant, 2.0–5.0 m. high, with a cluster of tuberous roots; stem varying in colour from pale or dirty white to brown, marked by numerous scars left by fallen leaves; leaves palmate, pale green in colour with 5–9 lobes; flowers unisexual, grouped in terminal cymes: male and female flowers on same inflorescence; fruit a capsule containing three seeds resembling castor seed.

Cassava is a native of S. America and has been introduced from there into Africa, India, countries of S. E. Asia and the Pacific Islands. Two types of cassava are recognized, the bitter and the sweet, according to the taste of the tuberous root. Some authorities assign the sweet types to a distinct species, variously designated as *M. palmata, M. dulcis* or *M. aipi*. This differentiation has not been generally accepted, as the taste of the tuber is not regarded as a character of specific or varietal importance; a bitter type in one area may become a sweet one when transferred to another or vice versa. Within the species, several types or races are recognized, based on the length of growth period, plant habit, colour of leaf, and the number, size, shape, length, diameter and colour of roots; the distribution of pigment in various parts of the plant and even the length of time required to cook the root are taken as criteria for the differentiation of types. Based on these characters, 75 types have been recognized in Kerala; one of them is a variegated type with ornamental foliage, often cultivated in gardens (van Royen, I, 99; Burkill, II, 1411–15; Bailey, 1947, II, 1993; Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 206; Chandraratna & Nanayakkara, *Trop. Agriculturist*, 1944, **100**, 219; *Rep. Dep. Res., Univ. Travancore*,

*Cassava or Manioc is the name generally applied to the plant and Tapioca to the starch prepared from its tubers. In India, both the plant and the starch extracted from its tubers are called Tapioca.

FIG. 93. MANIHOT ESCULENTA—FLOWERING AND FRUITING BRANCH

1939-46 ; 108 ; Abraham, *Farm Bull., Indian Coun. agric. Res.*, No. 17, 1956 ; Rao, *Madras agric. J.*, 1951, **27,** 57).

Considerable work has been carried out in India on the improvement of cassava by hybridization between pure lines ; selected hybrids have been maintained by vegetative propagation. Promising types evolved in Kerala include *Hybrids 105, 96, 9/49* and *20/50*. Inbreeding of cultivated types has shown that a large number of them are heterozygous in nature. Interspecific hybridization of *M. esculenta* with two other species, *M. saxicola* Lanjouw and *M. glaziovii* Muell. Arg. (Ceara Rubber), has been carried out particularly with a view to improve the protein content of tubers. Hybridization with the former has not yielded useful results. In the case of hybridization with *M. glaziovii*, however, good results were obtained by back-crossing clonal types of F_1 hybrids with the cassava parent. The fourth backcross generation is almost similar to cassava and exhibits favourable combinations of characters, like high yield, increased vigour, resistance to drought and spreading habit of roots. The tubers of the hybrid plants are as good as cassava for eating.

The chromosome number in all types of cassava is reported to be $2n=36$. Tetraploids produced by colchicine treatment of axillary buds are more vigorous than normal plants, but the yield of tubers is poor. Triploids obtained by crossing tetraploids with diploids have shown some superiority over tetraploids (*Rep. Dep. Res., Univ. Travancore*, 1939-46, 108 ; Abraham, *Indian J. Genet.*, 1957, **17,** 212 ; *Annu. Rep. Indian Coun. agric. Res.*, 1954–55, 42 ; Bolhuis, *Euphytica*, 1953, **2,** 107).

Cultivation

Cassava is cultivated nearly throughout the humid tropics particularly in South and Central America, Central and West Africa and S. E. Asia. The chief areas of cultivation are Brazil, Congo, Nigeria and other countries of equatorial Africa, Indonesia and India. The world acreage is estimated at 17 million, of which more than half is concentrated in tropical Africa (Table 1). In India, cassava has been grown as a subsidiary food crop in Kerala for a century or more ; it became a crop of importance since the beginning of World War II, when due to disruption of supplies of starch from western countries and also shortage of rice due to Japanese occupation of Burma, cassava cultivation received an impetus. Further, cassava was recognized as an excellent raw material for sago manufacture and sago from this source has almost wholly displaced the product from sago palm, formerly imported from Indonesia (van Royen, I, 99 ; *Prod. Yearb. FAO*, 1959, **13,** 79, Table 25 ; Pynaert, 160 ; Cerighelli, I, 290 ; *Rep. Tapioca Enquiry Comm.*, Travancore-Cochin, 1952, 1–2, 16–18).

The main cassava growing areas in Kerala are confined to the narrow belt of undulating land, between the littoral tract and the hills. The bulk of the acreage is in Quilon, Trivandrum, Kottayam, Malabar and Trichur districts. In these areas, the plant is cultivated in small holdings, one acre or less in area, mainly for local consumption. It is sometimes grown as a subsidiary crop in tea and rubber plantations. In Madras, which ranks next to Kerala in acreage, cultivation is concentrated in Salem, S. Arcot and Kanyakumari districts. Table 2 summarizes the acreage under this crop in India and

production of cassava during the past few years (*Agric. Marketing India, Rep. Marketing of Tapioca in India, Marketing Ser.*, No. 88, 1955, 3; *Rep. Tapioca Enquiry Comm.*, Travancore-Cochin, 1952, **21**, 27, appx J N).

Cultivated types—In India, as in other countries, the types under cultivation are either chance seedlings or bud mutations selected for desirable characters and maintained by vegetative propagation. For edible purposes, strains with high starch and protein content, and little or no hydrocyanic acid, are preferred. For starch manufacture, high yielding strains are used even though they contain hydrocyanic acid, since they are not browsed by cattle and can be grown in forest areas without much protective measures against theft, or browsing by animals. Cassava types grown in Kerala may be classified into two groups; long duration types maturing in 10–12 months and short duration types maturing in 7–8 months. The former are used generally for starch and sago manufacture; short duration types are used for cooking and edible purposes. The principal commercial types grown in Kerala are: *Kalikalan* in South Travancore; *Aryan* and *Nedumangadan* in Central Travancore; and *Kattan* and *Vella* in North Travancore. Other types popular in North Travancore are: *Elamurain, Thulavella, Vellarotti, Nentran* and *Sundari Vella*. Besides these, two hybrid progenies, *Hybrid 105* and *Hybrid 96*, have been distributed for cultivation (*Rep. Tapioca Enquiry Comm.*, Travancore-Cochin, 1952, 21; *Rep. Marketing Tapioca*, 1955, 4–5; Holleman & Aten, 5).

TABLE 1—ACREAGE AND PRODUCTION OF CASSAVA IN SOME IMPORTANT COUNTRIES*

	Area (thousand acres)				Production (thousand tons)			
	1948 52 (av.)	1956	1957	1958	1948 52 (av.)	1956	1957	1958
Brazil	2,367	2,911	2,948	2,827	12,269	15,074	15,199	14,609
Indonesia	2,157	2,780	3,017	3,249	6,710	8,987	9,958	10,799
India	586†	610	609	614	1,326†	1,764	1,759	1,768
Congo	1,619	1,554	1,705	1,572	5,818	7,357	7,657	7,429
Nigeria	2,469	1,401	1,621	1,688	10,553	5,895	8,100	8,439
Total**	14,579	16,062	17,050	16,556	51,179	58,560	61,316	62,103

* *Prod. Yearb. FAO*, 1959, **13**, 79, Table 25. † 1949 53.
** Data includes countries not mentioned above and also estimates for countries for which data are not available.

TABLE 2—ACREAGE AND PRODUCTION OF CASSAVA IN INDIA*

State				Production (tons)		
	1956 57	1957-58	1958 59	1956 57	1957-58	1958 59
Kerala	557,900	557,900	557,900	1,569,094	1,569,094	1,569,094
Madras	43,200	42,868	43,040	165,860	165,810	161,250
Assam	4,250	4,120	2,920	9,486	9,196	3,259
Andhra Pradesh	2,695	7,348	3,874	6,932	21,864	11,686
Mysore	595	882	928	4,314	834	875
Orissa	360	228	228	978	43	43
Bombay	195	195	195	1,270	1,270	1,270
Tripura	130	50	40	520	175	80
West Bengal	100	(a)	(a)	918	(a)	(a)
Andaman & Nicobar Is	28	30	30	103	110	110
Total	609,453	613,621	609,155	1,759,475	1,768,396	1,747,667

* Data obtained from the Directorate of Econ. & Statist., Minist. Food & Agric., Govt. of India.
(a) negligible.

Climate & Soil—Cassava prefers a warm, humid climate with ample rainfall and sunshine. It does not stand frost and does not flourish above an altitude of 900 m. Provided there is adequate moisture at the time of planting, the crop can withstand drought for some time; too little rainfall results in woody tubers. A fairly well-spread rainfall of about 150 cm. is considered to be optimum, but it can stand heavy rainfall of even 250 cm. A light, well-drained soil of medium fertility is preferred; very rich or very poor soils are unsuitable. In Kerala, the crop is grown on lateritic loams which though clayey can be improved and enriched by the addition of leaf mould, ashes and house-hold refuse. Saline soils and sticky soils subject to water-logging are unsuitable. Newly cleared virgin soil can be used, but as they are usually very fertile vegetative growth is excessive and tuber maturity is delayed. Cassava is grown under irrigation in a few areas in Salem and Tanjore districts (Madras) but the total area under irrigated crop hardly amounts to 2% (Abraham, *Farm Bull., Indian Coun. agric. Res.*, No. 17, 1956; Grist, 164–65; Holleman & Aten, 2; Yegna Narayan Aiyer, 291; Sankaram, *Madras agric. J.*, 1942, **30**, 405; van Royen, I, 99; *Rep. Marketing Tapioca*, 1955, 3).

Cassava is generally grown as a pure crop; it can be raised also as a mixed crop with vegetables, banana, yams or sweet potato or as a subsidiary crop in young rubber and coconut plantations. Frequent cultivation of cassava in coconut plantations, however, is reported to be harmful to the main crop, since it depletes the soil of potash and favours multiplication of rats (Abraham, loc. cit.; Yegna Narayan Aiyer, 292; *Rep. Tapioca Enquiry Comm.*, Travancore-Cochin, 1952, 20; Sankaram, loc. cit.; Grist, 165, 167; Seshadri & Sayeed, *Bull Indian Cocon. Comm.*, 1953 54, **7**, 19; Menon, ibid., 1953–54, **7**, 187).

Propagation—Cassava is usually propagated by

FIG. 91. MANIHOT ESCULENTA—PART OF A PLANTATION

cuttings of the stem. Propagation from seeds is resorted to only for purposes of selection and hybridization. For propagation by cuttings, harvested stems are cut, tied into bundles and stacked upright in sheltered places for 2–12 weeks. In some areas, the material is planted in the first instance in channels 2 ft. × 3 ft. × 10 ft., and covered with earth; leaf buds sprout out in 10–12 days and stems are then dug out, cut into setts and planted in the field. Cuttings from lower and middle zones put forth vigorous shoots and yield a large number of tubers. The cuttings are usually 6–9 in. long though longer cuttings, *c.* 18 in., are reported to give significantly higher yields. Planting of excised young shoots from parent cuttings, after hormone treatment, has given promising results (Abraham, loc. cit.; Holleman & Aten, 5; Grist, 165–66; Krishnamurthy, *Madras agric. J.*, 1949, **36,** 523; Mudaliar, ibid., 1951, **38,** 5; Jeyaseelan, *Trop. Agriculturist,* 1951, **107,** 168; Fernando & Jayasundara, ibid., 1942, **98,** 3; *Madras agric. J.*, 1922, **10,** 22; Uttaman, ibid., 1952, **39,** 468; Yegna Narayan Aiyer, 292; Chant & Marden, *Trop. Agriculture, Trin.*, 1958, **35,** 195).

Planting is done in shallow pits or on mounds and ridges. The field is thoroughly ploughed up and a basal dressing of farmyard manure is applied. Small pits are dug 3–3.5 ft. apart (both ways) in a square pattern; spacing may be less in intensively cultivated areas. Stem cuttings are planted, one in each pit or mound, in a vertical position, burying *c.* 2 in. of the lower end in the soil. In some areas, 2 or 3 cuttings are planted in each pit in a slanting position, while in some others, cuttings are planted horizontally. Vertical planting is reported to give the best results (Abraham, loc. cit.; Barker, *Bull. Dep. Ind. Travancore*, No. 14, 1921; Holleman & Aten, 6; Yegna Narayan Aiyer, 292–93; Jeyaseelan, loc. cit.).

For ridge planting, rows are opened 3–4 ft. apart and setts are planted in a slanting position. For making mounds, the ridges are cut by narrow cross channels and one sett is planted on the top of each mound (Barker, loc. cit.; Mudaliar, loc. cit.).

Cassava is planted soon after the advent of or during the course of the monsoon. If facilities for irrigation are available, planting may be done in late summer so that the crop is well established by the time monsoon sets in. Planting at the beginning of the monsoon is preferred if the tubers are required for starch manufacture. In many parts of Kerala, planting is done almost throughout the year. In North India, the crop may be planted from February to April after the cold weather (Abraham, loc. cit.; Holleman & Aten, 7; Sankaram, loc. cit.; *Rep. Marketing Tapioca,* 1955, 6).

Manuring—Cassava is an exhausting crop and in places where it is grown continuously, some form of crop rotation, green manuring, or application of organic or inorganic fertilizers is essential. Cattle manure is usually applied alone or in combination with green manure; sometimes lime and wood ash are added. They are applied to the soil in the initial stages of cultivation and supplementary doses of ash, muriate of potash and oilcakes are applied as top dressings during intercultivation. Sheep are penned in some areas of Madras; tapioca mill wastes are applied as manure in Salem. Fish manure and ammonium sulphate or ammonium phosphate and sulphate of potash are also used. The yield increases with increased doses of farmyard manure but when applied in excessive quantities the roots are reported to become bitter (Abraham, loc. cit.; *Rep. Tapioca Enquiry Comm.*, Travancore-Cochin, 1952, 92–96; Mudaliar, loc. cit.; Krishnamurthy, loc. cit.; Grist, 168; Tobias, *Cocon. Bull.*, 1958–59, **12,** 44).

Intercultivation at short intervals is necessary till the plants grow up and cover the ground. Cuttings that do not develop are replaced up to a month of original planting. The plants are earthed up when about 4 months old. The plants grow to a height of 8–10 ft. or even more. For good root development only two to three shoots per sett are retained; plants are topped, in some areas, to a height of six feet (Abraham, loc. cit.; Holleman & Aten, 6; Yegna Narayan Aiyer, 292).

Diseases & Pests—Cassava crop is not subject to any serious disease or pest in India. Leaf spot caused by *Cercospora henningsii* Allesch. and *C. cassavae* has been reported from several areas. It can be controlled by spraying with Bordeaux mixture. *Fomes lignosus* Klotzsch and *Phytomonas* sp. are reported to cause rotting of tubers.

Cassava mosaic is by far the most serious disease. It is controlled by destroying plants showing symptoms of the virus. Mosaic resistant types are reported to have been evolved in East Africa (*Mem. Dep. Agric. Madras*, No. 36, 1954, 1183; *Indian J. agric. Sci.*, 1950, **20,** 107; Abraham, loc. cit.; Chant, *Emp. J. exp. Agric.*, 1959, **27,** 55).

The scale insect, *Aonidomytilus albus* Ckll., is reported to attack the crop in Madras. In the earlier stages of the attack, leaves lose chlorophyll and dry

I.C.A.R., New Delhi

FIG. 95. MANIHOT ESCULENTA—TUBERS

up; when heavily infested, the stem also dries up. Parathion affords effective control. The pest can be checked by planting healthy setts and removing infested plants in an early stage (Anantanarayanan *et al.*, *Madras agric. J.*, 1957, **44**, 281).

Tetranychus telarius Z. (Red spider mite) is frequently found on the under surface of lower leaves, leading to yellow spotting and general discolouration. Affected leaves are removed and burnt; in severe cases, plants are dusted with lime-sulphur mixture. The oyster shell scale insect, *Lepidosaphes* sp. has been reported in a few areas in Travancore during summer months. Eradication by insecticidal sprays is difficult and complete destruction of affected plants is recommended. Soft mealy bugs have also been reported to attack tapioca plants (Abraham, loc. cit.).

Harvesting & Yield—The crop is ready for harvesting from the eighth month onwards. The maturity of tubers is indicated by the flowering of plants and by the yellowing and shedding of leaves; cracking of soil surface beneath the plant indicates that roots are fully developed. If tubers are required for marketing as vegetable, they are dug out when the crop is six to eight months old; if required for sago or starch manufacture, harvesting is delayed by another 2 or 4 months. Tubers can be left in the ground for a few months longer without damage (Krishnamurthy, loc. cit.; Abraham, loc. cit.; Mudaliar, loc. cit.).

For harvesting, the plants are pulled out and tubers separated. Each plant yields 5–10 cylindrical tubers, usually, 12–18 in. long, sometimes reaching 2–3 ft. The weight of a single tuber usually varies from 2–5 lb.; in long duration types, roots weighing as much as 25–30 lb. have been reported (van Royen, I. 99; Yegna Narayan Aiyer, 293).

The yield of tubers per acre in Kerala varies widely from 1 to 12 tons, the average being 5 tons. Trials carried out at Travancore have shown that

under intensive cultivation yields up to 20 tons per acre can be secured. In Malaya and other countries, yields up to 25 tons per acre are reported. The starch content is highest when the tubers are fully mature and the net starch yield per acre is higher from cassava than from any other cultivated crop including rice (*Rep. Marketing Tapioca*, 1955, 8 : Abraham, loc. cit. ; Holleman & Aten, 7, 9).

Storage—Harvested tubers do not keep well for more than 4-5 days. Rotting is brought about by organisms like *Penicillium*, *Rhizopus*, *Aspergillus*, yeast and a *Bacillus* sp. Coating with fungicidal wax is reported to extend storage life to 16 days ; treatment with a mixture of ethylene dibromide and ethyl bromide (1 : 1) or with formalin diluted with water (1 : 33) extends the life to 19 and 25 days respectively. Tubers may be stored under cold storage (temp. 32-35°F. and R.H. 85-90%) up to six months (Subramanyam & Mathur, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1955-56, **5**, 110 ; Majumder, ibid., 1954-55, **4**, 164 : Majumder *et al.*, ibid., 1955-56, **5**, 108 : Kirpal Singh & Mathur, ibid., 1952-53, **2**, 181).

Composition and Utilization

Cassava is the staple food of the poorer section of the population in many tropical countries, particularly Central and South America, Central and West Africa, Indonesia and Polynesian Islands. It is consumed, like sweet potato, in the form of tubers, chips, flour and sago. In India, cassava, along with fish, forms the main item of diet of the working classes in Kerala. Young tubers, particularly of sweet varieties, are consumed after roasting or boiling, like potato. As fresh tubers do not keep well for long, they are cut into slices and dried. Dried slices can be stored for several months. They are cooked and eaten or powdered into flour and used in the same manner as rice flour. In Philippines, tubers are grated, juice squeezed out and the residue made into pellets ; under the name Cassava Rice, dried pellets are used as a substitute for rice and maize. The most important commercial use for cassava is the production of starch and sago ; they are produced both on cottage and industrial scale in many cassava-producing countries, including India (van Royen, I, 99 ; *Rep. Tapioca Enquiry Comm.*, Travancore-Cochin, 1952, 33-37 ; *Rep. Marketing Tapioca*, 1955, 27-28 ; Holleman & Aten, 15 ; Burkill, II, 1417-19).

Chemical composition—Analysis of the edible portion of fresh tubers gave the following values: moisture, 59.4 ; protein, 0.7 ; fat, 0.2 ; carbohydrates, 38.7 ; and mineral matter, 1.0% : calcium, 50 ; phosphorus, 40 ; iron, 0.9 ; thiamine, 0.045 ; nicotinic acid, 0.3 ; and riboflavin, 0.01 mg./100 g. The starch content of the tuber varies with the type and the conditions of growth ; analysis of the edible portion (77.5-88.5% of the tuber) of 27 types grown in Kerala showed that the starch content varied from 78.1 to 90.1%, dry wt. basis (*Hlth Bull.*, No. 23, 1951, 36 ; *Rep. Tapioca Enquiry Comm.*, Travancore-Cochin, 1952, 35 ; *Rep. Dep. Res., Univ. Travancore*, 1939-46, 117-18).

The starch content increases with the growth of tubers, reaching a maximum between the eighth and twelfth months after planting ; thereafter it decreases and the fibre content increases. The starch contains 20% amylose. *In vitro* digestion with taka diastase and pancreatic amylase shows that 48.3% of the starch present in raw tubers and 77.9% of starch present in cooked tubers are readily hydrolysed. Other carbohydrates present in the tubers in minor quantities are glucose, fructose, sucrose, dextrins, pentosans and mucilage (Sreeramamurthy, *Indian J. med. Res.*, 1945, **33**, 229 ; Mukundan, *Rep. Dep. Res., Univ. Travancore*, 1939-46, 399 : Brautlecht, 213).

The tuber contains small quantities of albumin, globulin and glutelin ; prolamine is present in negligible amounts. The essential amino acids present in the total proteins (1.33% in the sample) are (g./16 g. N): arginine, 7.74 ; histidine, 1.50 ; isoleucine, 5.33 ; leucine, 5.56 ; lysine, 6.23 ; methionine, 0.60 ; phenylalanine, 3.45 ; threonine, 3.83 ; tryptophan, 0.53 ; and valine, 4.51. Methionine is the limiting amino acid ; some workers have reported its complete absence. Cassava proteins are comparable to rice proteins in digestibility ; the biological value (Block & Mitchell equivalent) of the total proteins is 48% (Kuppuswamy *et al.*, 108 ; Sreeramamurthy, *Indian J. med. Res.*, 1945, **33**, 229 ; 1951, **39**, 332 ; Ramachandran & Phansalkar, ibid., 1956, **44**, 501).

Non-protein nitrogen accounts for nearly half the total nitrogen of the tuber. The non-protein fraction is rich in free lysine ; it contains histidine, cystine, arginine, tyrosine and tryptophan (Sreeramamurthy, *Indian J. med. Res.*, 1945, **33**, 229).

The tuber is a fair source of calcium and phosphorus. Analysis of the ash of peeled tuber gave the following values: potassium (as K_2O), 41.63 ; sodium (Na_2O), 1.20 ; calcium (CaO), 10.64 ; magnesium (MgO), 7.35 ; iron (Fe_2O_3), 0.66 ; phosphorus (P_2O_5), 15.58 ; sulphur (SO_3), 3.73 ; silica (SiO_2), 0.94 ; chlorine, 2.75 ; and CO_2, 9.14% ; iodine content of tuber,

12 μg./kg. (Winton & Winton, II, 87 ; Iodine Content of Foods, 66).

The juice of fresh tuber contains phosphorylase and Q-enzyme ; the former catalyses the formation of amylose from glucose-1-phosphate and the latter helps in the synthesis of amylopectin from amylose. The tuber contains also pyro- and glycero-phosphatases but no phosphatase ; α- and β-amylases have not been identified (Murthy *et al.*, *J. sci. industr. Res.*, 1954, **13B,** 223 ; Swaminathan, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1955–56, **5,** 193).

A cyanogenetic glucoside, linamarin ($C_{10}H_{17}O_6N$, m.p. 142–43°), and an enzyme linase which hydrolyses it are present in the tuber ; some hydrocyanic acid is also present in the free state. Bitter types contain up to 0.077% hydrocyanic acid, while sweet types contain less than 0.016% (fresh wt. basis). The acid is concentrated mostly in the inner rind ; flesh and outer rind contains but small quantities. The major part of the toxic principle can be eliminated by peeling the tuber and washing before consumption. Sun-drying after slicing destroys *c.* 75% of the acid and cooking with water for 5 minutes removes more than 80%. Commercial tapioca flour of peeled tubers and *suji* contain negligible quantities of hydrocyanic acid ; analysis of samples showed that the former contained *c.* 3 p.p.m. while the latter gave a value of *c.* 21.6 p.p.m. Few cases of poisoning due to tapioca consumption have been reported (Murthy, Ph.D. Thesis, Nagpur University, 1955 ; Holleman & Aten, 10–11 ; Joachim & Pandittesekere, *Trop. Agriculturist*, 1944, **100,** 150).

Young leaves of sweet varieties of cassava plant are eaten as vegetable. They contain 20.6–36.4% crude protein (on dry wt. basis) ; they are also rich in vitamins and minerals. Analysis of fresh leaves (from Philippines) gave the following values: moisture, 81.9 ; nitrogen, 1.183 ; fat, 1.67 ; crude fibre, 2.10 ; and ash, 1.46% ; calcium, 124.3 ; phosphorus, 81.8 ; iron, 5.64 ; carotene, 10.774 ; thiamine, 0.270 ; riboflavin, 0.342 ; niacin, 1.74 ; and ascorbic acid, 256.6 mg./100 g. Leaves and stems are used as feed for livestock ; leaves are considered suitable for rearing silkworms. Dehydrated meal prepared from cassava leaves is superior to alfalfa leaf meal in vitamin A and protein content and can be used as an ingredient of dairy feed mixtures. The leaves of some varieties of tapioca contain hydrocyanic acid (up to 89 mg./100 g.) ; they can be rendered safe for feeding by steeping in boiling water [Holleman & Aten, 9 ; Rogers, *Econ. Bot.*, 1959, **13,** 261 ; Charavanapavan, *Trop. Agriculturist*, 1944, **100,** 164 ; *Chemurg. Dig.*, 1950, **9**(10), 10 ; Intengan *et al.*, *Philipp. J. Sci.*, 1954, **83,** 208 ; Lander, 269 ; Joachim & Pandittesekere, *Trop. Agriculturist*, 1944, **100,** 150].

Cassava (Tapioca) Products

Tapioca chips—Two kinds of chips are prepared : plain dried (white chips) and parboiled chips. The former are prepared from peeled tubers by slicing and sun-drying ; parboiled chips are prepared by drying slices previously immersed in boiling water for 10 minutes. Both types are consumed after cooking or frying. White chips are used for the preparation of tapioca flour ; inferior grades of chips are used as a substitute for grains in animal feeds. They are particularly valued for fattening pigs (*Rep. Marketing Tapioca*, 1955, 27–28 ; IS : 1317–1958 ; 1509–1959).

Plain dried and parboiled dried chips are classified in the trade into three grades : Grade I, pure white with skin and rind removed ; Grade II, pure white with only skin removed ; Grade III, dull brownish, due to improper drying or delayed conversion of tubers. Table 3 gives the Indian standard specifications for chips.

Dried chips are stored in wooden bins or rooms. White chips keep well for 6 months in the dry season, but are liable to get mouldy in about 3 months during the monsoon. Parboiled chips keep well for 12 months. Stored chips are subject to infestation by *Araecerus fasciculatus* DeG. and *Stegobium paniceum* L. Storage in jute bags impregnated with Lindane-Dieldrin mixture is recommended ; fumigation of stores with methyl bromide and ethylene dibromide is effective in controlling insect infestation (*Rep. Tapioca Enquiry Comm.*, Travancore-Cochin, 1952, 22 ; Pingale *et al.*, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1955–56, **5,** 134).

Tapioca flour—Tapioca flour, prepared by grinding white chips is used in confectionery, biscuits and other processed foods. It is used also as an adulterant of cereal flour. Blends of wheat and tapioca flour are used in the preparation of bread and *chapati*. Trials have shown that tapioca flour can be mixed with wheat or rice flour up to 25% without affecting the nutritive value. There is a distinct improvement in growth rate of rats, when fed on rice-tapioca diet, as compared to rats fed on rice alone. Table 4 gives the chemical composition of tapioca flour (*Rep. Marketing Tapioca*, 1955, 28 ; Abraham, *Farm Bull., Indian Coun. agric. Res.*, No. 17, 1956, 14 ; Subrahmanyan *et al.*, *Brit. J. Nutr.*, 1954, **8,** 1 ; *Food Sci.*, 1958, **7,** 4).

TABLE 3—STANDARDS FOR EDIBLE TAPIOCA PRODUCTS*
(figures give maximum permissible values)

	Starch	Sago†	Flour		Chips	
			Human consumption	Animal feed††	Human consumption	Animal feed††
Moisture, %	13.0	12.0	13.0	13.0	13.0	13.0
Total ash (dry basis), %	0.4	0.4	1.8	2.5	1.8	2.5
Acid insol. ash (dry basis), %	0.05	0.075	0.1	1.0	0.1	1.0
*p*H of aq. extr.	4.5 7.0	4.5 7.0	4.5 7.0	@	4.7 7.0	..
Crude fibre (dry basis), %	0.2	..	1.8	2.5	2.0	3.0
Size	(a)	(b)	(c)	(d)	12 mm. thickness	15 mm. thickness

* IS: 899 1956; 1319 1958; 1318 1958; 1510 1959; 1317 1958; 1509 1959.
† Loss of solids during cooking, $\not>$30%, with individual globules retaining original shape; colour of gelatinized alkaline paste in Lovibond scale, $\not>$1R+3Y; †† Hydrocyanic acid, $\not>$0.03; crude protein, $\not<$2.0; and crude fat, $\not<$0.4%, dry basis; (a) $\not>$2% retained on IS Sieve 8 (aperture 75 μ) and $\not>$0.5% on IS Sieve 15 (aperture 151 μ); (b) $\not<$95% shall pass through IS Sieve 170, but retained on IS Sieve 85; (c) $\not>$5% retained on IS Sieve 15; (d) $\not>$5% retained on IS Sieve 160 (aperture, 1.60 mm.).
@ Alcoholic acidity (as sulphuric acid), 0.15%.

TABLE 4—COMPOSITION OF TAPIOCA PRODUCTS AND NATURAL RICE
(figures give percentages)

	Tapioca flour*	Tapioca macaroni†	Tapioca macaroni† (coated with calcium caseinate)	Natural rice† (raw milled)
Moisture	9.5	10.6	9.8	12.5
Protein	1.6	11.2	14.4	6.6
Fat	0.4	1.9	1.9	0.5
Fibre	0.8	0.7	0.7	0.2
Ash	1.8	1.8		0.6
Carbohydrates	84.9	73.8	71.0	79.6
Calcium	0.06	0.05	0.22	0.01
Phosphorus	0.08	0.14	0.15	0.12
Iron, mg.	3.5	2.9	2.8	1.8
Thiamine, mg.	0.08	0.22	0.18	0.11
Nicotinic acid, mg.	1.10	3.7	3.6	1.2
Riboflavin, mg.	0.03	0.07	0.06	0.02

*Subrahmanyan, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1952 53, **2**, 48; † Subrahmanyan *et al.*, ibid., 1954 55, **4**, 55.

Tapioca chips and tapioca flour are in demand for the production of glues and adhesives. About 25,000 tons of tapioca flour are used by the wood veneer industry and a similar quantity for the manufacture of adhesives. Tapioca flour is also used as an ingredient of *Kumkum* used by women in India as a mark of decoration (Abraham, loc. cit.; *Rep. Marketing Tapioca*, 1955, 28).

Tapioca suji Tapioca *suji* is prepared from peeled tubers after slicing, washing, steaming, drying, grinding and finally grading the product. It is used as a substitute for wheat *suji* in the preparation of sweet and savoury dishes (Swaminathan *et al., Bull. cent. Fd technol. Res. Inst., Mysore*, 1952–53, **2**, 79; *Rep. Marketing Tapioca*, 1955, 28–29).

Tapioca starch—Tapioca starch is produced from washed and peeled tubers, by grinding with water and settling. Peeled tubers are washed and ground with water into a slurry or starch milk in mechanically or hand operated grinders. The slurry is passed through strainers to eliminate fibrous impurities and settled in tanks. Small quantities of sulphuric acid or alum may be added to the settling tank to aid sedimentation; sulphur dioxide or chlorine may be used for bleaching. The starch which settles at the bottom of the tank is repeatedly washed, dried and sieved. A yield of 20–25% of starch on the fresh weight of the tuber is obtained. Bitter types, e.g. *Nedumangadan* and *Kattan*, are preferred for the production of starch as they contain a high percentage of starch (*Rep. Marketing Tapioca*, 1955, 26–27; Holleman & Aten, 48–49).

Tapioca starch is composed of small granules, 5–35 μ (av. 15 μ) in size. It forms a thin, homogeneous adhesive paste of high viscosity when boiled with water. It is extensively employed in sizing and finishing textiles, laundering, paper making and manufacture of adhesives and cosmetics. Finishes from tapioca starch have a high gloss and are flexible and durable. For laundry use, it is regarded as inferior to rice starch. Tapioca starch is also used for edible

TABLE 5—PRODUCTION & CONSUMPTION OF TAPIOCA STARCH IN TEXTILE INDUSTRY*

	Production (tons)	Deliveri (tons)
1957	2,874	2,863
1958	2,583	2,546
1959	3,667	3,395

* *Statist. Bull. Cott. Text. Ind., Bombay.*

purposes, for making puddings, biscuits and confectionery (*Rep. Marketing Tapioca*, 1955, 27: IS: 1319–1958; Brautlecht, 225; *Rep. Tapioca Enquiry Comm.*, Travancore-Cochin, 1952, 46).

Tapioca starch can be used for the manufacture of glucose and dextrin and also for the fermentative production of alcohol. A process for the preparation of sweet syrups from tapioca starch has been developed: it consists in adding starch slurry, slowly and with constant stirring, to boiling water containing dilute hydrochloric acid and autoclaving. High conversion syrups suitable for table use are obtained by employing 0.3–0.35% hydrochloric acid: at lower concentrations of acid (0.2–0.25%), syrups useful for fruit canning are obtained (*Rep. Marketing Tapioca*, 1955. Krishnamurti, *Curr. Sci.*, 1960, **29**, 346: Desikachar *et al.*, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1952–53, **2**, 180).

Tapioca starch is manufactured mainly on a cottage industry basis in Kerala and to some extent in Madras; there are also a few large scale factories. Considerable quantities of starch are distributed to consuming centres throughout India. Table 5 gives the consumption of tapioca starch by the textile industry in recent years. Three grades of tapioca starch are recognized. The best grade is bright white in colour with no foreign matter and has not more than 12% moisture and 0.2% total ash. Standard specifications for various tapioca products are given in Table 3 (*Rep. Marketing Tapioca*, 1955, 30–32).

Tapioca sago—For the production of sago, the tubers are processed in the same way as for starch. Washed starch from settling tanks is dried in the sun to *c.* 50% moisture and made into globules by shaking in cloth bags or by the use of mechanically operated granulators. The globules are then graded by passing through standard sieves. They are gelatinized by roasting them for *c.* 15 minutes on hot pans smeared with coconut oil. They are finally dried in a hot air drier (40–50°). The yield of sago is reported to be *c.* 25% of the weight of fresh tubers [*Rep. Marketing Tapioca*, 1955, 12, 22; *Indian Tariff Bd, Rep. on the Sago (Tapioca globules) Industry*, 1950; *The Indian Sago Industry*, Cent. Fd technol. Res. Inst., Mysore, 1955, 17; Subrahmanyan *et al.*, *Sci. & Cult.*, 1959–60, **25**, 343].

Tapioca sago is produced by a number of small and big units, mostly located in Salem district (Madras State). Production has gone up considerably since World War II. From about 40 units with an out-turn of 22,873 tons in 1950, the number of units increased to 125 in 1958 with a production of 38,968 tons. Total production capacity of sago factories is estimated at 53,000 tons. Table 6 gives the production of sago in India. The industry is in a position to meet all domestic demands and has sufficient surplus for export. The industry has enjoyed tariff protection during 1950–59. There is practically no import of sago into India at present. Sago globules are classi-

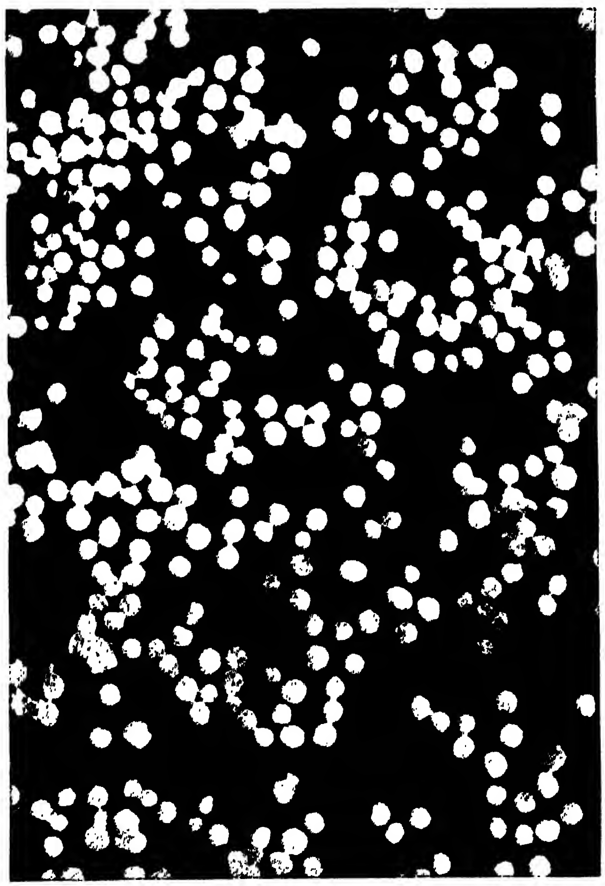


FIG. 96. MANIHOT ESCULENTA—SAGO GLOBULES

TABLE 6—PRODUCTION OF SAGO*

	Qty (tons)
1951	22,873
1952	21,868
1953	24,000
1954	18,086
1955	22,041
1956	30,817
1957	37,213
1958	38,968

* Information from Salem Sago Manufacturers' Association; *Tariff Commission, Rep. on the Continuance of Protection to Sago (Tapioca globules) Industry*, Govt. of India, 1954, 1957, 1959.

fied into four grades according to size, colour and degree of roasting. The grades are: Grade I, milky white globules, well roasted; Grade II, colour slightly dull, but well roasted; Grade III, colour dull, but containing a small percentage of half roasted globules; and Grade IV, other than those specified above. Sago is packed in gunny bags (205 lb./bag) for the market.

The quality of tapioca sago depends largely on the quality of starch from which it is derived. Well gelatinized globules with a creamy white lustre are comparable in quality and nutritive value to imported palm sago. Analysis of 21 samples, collected from different factories in Salem, gave the following ranges of values (av. figures in brackets): moisture, 11.1–13.1 (12.2); nitrogen, 0.012–0.024 (0.02); total ash, 0.12–0.49 (0.25); acid insol. ash, 0.01–0.16 (0.06); fibre, 0.0–12.5 (5.6); and loss of solids during cooking, 5.2–45.4 (21.3) %; *p*H of aqueous extr., 4.2–5.2 (4.8); colour of gelatinized alkaline paste (Lovibond units), 0.7 R + 1.0 Y to 1.2 R + 3.9 Y (1 R + 2.1 Y). The majority of samples conformed to the Indian standard specifications for sago (Table 3) (Subrahmanyan *et al., Bull. cent. Fd technol. Res. Inst., Mysore*, 1955–56, **5**, 77; *Rep. Sago Expert Comm.*, Minist. Comm. & Ind., Govt. of India, 1956, 14).

Sago is used as infant and invalid food and for the preparation of puddings. It is commonly consumed as a porridge, mixed with milk and sugar, or after soaking in curd or butter milk with salt and spices. *In vitro* digestibility studies have shown that cooked sago is digested to a greater extent than uncooked sago; the latter is digested at a faster rate than raw starch. No appreciable difference was observed in the digestibility of uncooked or cooked sago prepared from different starches (*The Indian Sago Industry*, Cent. Fd technol. Res. Inst., Mysore, 1955, 6, 18; Rao, *Mysore agric. J.*, 1951, **27**, 70; Sur *et al., Bull. cent. Fd technol. Res. Inst., Mysore*, 1955–56, **5**, 1).

A product similar to sago, but somewhat coarse, is produced in Indonesia, and is known in the trade as Tapioca Flakes. It is produced by rubbing moist starch (*c.* 50% moisture) against a screen (20 mesh/inch) and baking the grains in shallow pans (Holleman & Aten, 71–72).

Tapioca waste—The fibrous waste obtained as a by-product (yield, 10–20%) in the extraction of starch and sago is locally known as *tippi*. Analysis of a dried sample of *tippi* from a sago factory in Salem gave the following values: moisture, 11.2; crude protein, 0.85; fat, 0.3; starch, 56.2; crude fibre, 10.6; reducing sugars, 1.2; hemicellulose, etc., 18.2; and ash, 1.45%. A process has been worked out for the recovery of starch (yield, 22–28%) from the waste. Tapioca waste is used as feed for cattle and pigs and as raw material for the production of adhesives (Subrahmanyan *et al., Bull. cent. Fd technol. Res. Inst., Mysore*, 1955–56, **5**, 80; *Rep. Marketing Tapioca*, 1955, 28; *The Indian Sago Industry*, Cent. Fd technol. Res. Inst., Mysore, 1955, 25; Grist, 167).

Tapioca macaroni—This product, developed at the Central Food Technological Research Institute, Mysore, is essentially a blend of tapioca flour (60 parts), low-fat groundnut flour (15 parts) and wheat semolina (25 parts). The ingredients are mixed, kneaded after adding boiling water into a dough and extruded under pressure through a rice die provided with mechanical cutters. The product is dried by blowing hot air at 120°. Dried grains are given a thin coat of calcium caseinate. The finished product has the appearance of undermilled rice and fair keeping quality. It can be cooked and consumed in the same way as rice; the cooking time is, however, much less (5–6 min.). It contains almost twice as much protein as rice and is richer in minerals and vitamins (Table 4). It is superior to rice in nutritive value and feeding trials on school children have confirmed its utility as a food grain (Subrahmanyan *et al., Nature, Lond.*, 1954, **174**, 199; *Bull. cent. Fd technol. Res. Inst., Mysore*, 1953–54, **3**, 162; 1954–55, **4**, 55; *Food Sci.*, 1958, **7**, 87).

Tapioca macaroni has been produced on a pilot scale (1 ton/day) at the Central Food Technological Research Institute, Mysore, in three forms, viz. rice-

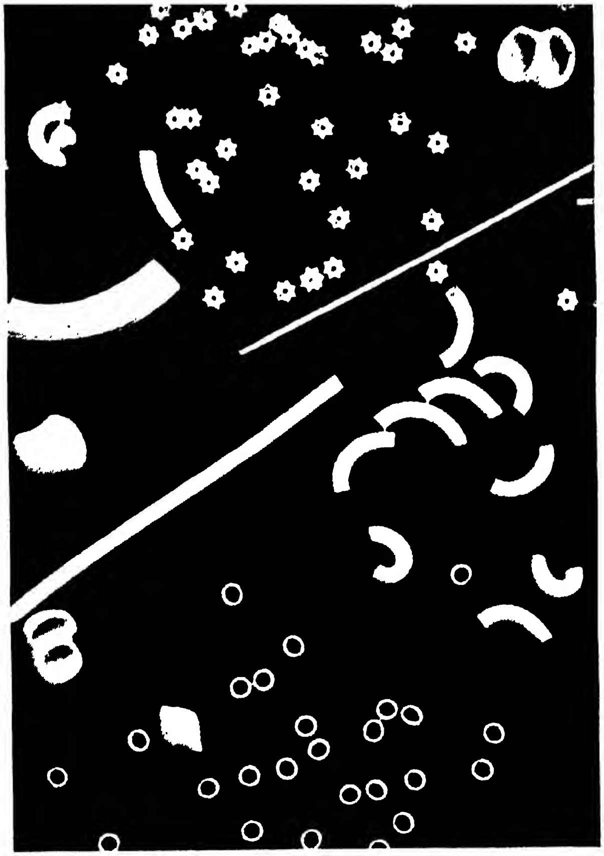


FIG. 97. MANIHOT ESCULENTA—DIFFERENT TYPES OF MACARONI

shaped grains, short tubes and shells; the cost works out to 25 nP./lb. The Government of Kerala are planning to install a plant with a capacity of 20 tons per day (Subrahmanyan *et al.*, *Res. & Ind.*, 1958, **3**, 270; Balu & Parpia, *Bull. Fd Sci. Ext. Serv.*, No. 1, 1958).

Other products—A granular product, called Farinha, is prepared in S. America from tapioca by pressing out the juice in a wooden screw presas and fermenting the pulp for *c.* 3 days. The fermented material is pounded and rubbed through a sieve to yield a meal which is then roasted over a slow fire. The product is used as food in times of emergency (Holleman & Aten, 14–15).

In S. America and West Indies, the juice squeezed out from the tubers is concentrated into a sauce (Cassareep) which can be kept indefinitely. It is used as aperient and as preservative for fish and meat (Holleman & Aten, 15).

Trade—A small quantity of tapioca sago is exported to some neighbouring countries. Tapioca flour and

TABLE 7—EXPORT OF TAPIOCA FLOUR FROM INDIA
(Qty in cwt.)

Country	1957	1958	1959
West Germany	55,596	549,941	586,745
Netherlands	4,916	163,560	98,872
Belgium	989	31,507	23,718
Ceylon	159	1,595	1,169
Br. Somaliland	1,000	..	.
Total Qty (cwt.)	62,660	746,603	710,504
Total Val. (Rs.)	800,022	8,446,850	7,428,269

starch are in demand in some countries of Europe. Table 7 summarizes available information on the export of tapioca flour from India in recent years. Small quantities of tapioca chips were exported in 1958, mainly to West Germany (2,954 cwt.) and Netherlands (2,000 cwt.).

M. glaziovii Muell. Arg. CEARA RUBBER, MANICOBA RUBBER

D.E.P., IV, 374; C.P., 657; Bailey, 1947, II, 1992.

A small laticiferous tree, 10–12 m. high, with a thick bark which peels off in horizontal strips. Leaves 3–7 palmipartite, long petioled; flowers unisexual; fruits capsular, sub-globose, 2–5 cm. in diam.; seeds flattened with hard coat, mottled grey and brown.

M. glaziovii is a native of the semi-arid north-eastern area of Brazil, introduced into this country and reported to thrive well in Nilgiri hills, Malabar, Assam and Orissa, up to an elevation of 1,200 m. It was formerly cultivated in Coorg (Mysore State) for its latex. It is easily propagated by seed or by cutting and is often grown as a hedge plant in parts of Kerala. It is hardy and requires little attention when once established; it grows fast and attains a height of *c.* 12 m. and a girth of 75 cm. in a few years (Schery, *Econ. Bot.*, 1949, **3**, 240; Abraham, *Indian J. Genet.*, 1957, **17**, 212; Troup, III, 854).

The tree is tapped for latex when 4–5 years old. The latex coagulates immediately on exposure but coagulation may be delayed by removing pieces of bark at the tapping site and painting with dilute acetic, citric or carbolic acid. The yield of latex from plants grown in India is poor; the quantity of rubber averages to 1 oz. per tree, as against 4 oz. and upwards per tree reported from some other countries. A great deal of variability in yield is observed between individual plants and it has been suggested that those

FIG. 98. MANIHOT GLAZIOVII—FLOWERING AND FRUITING BRANCH

yielding a thin watery latex should be rejected, by test tapping when they are 2 years old, and replaced by types giving thick latex; however, some trees which give unsatisfactory yields in the beginning are known to yield better when they become older. The horny outer bark makes tapping difficult and wounds caused by tapping do not heal quickly in moist areas. Further, the tree is not adapted for continuous tapping and the average yield of rubber is poor when compared to that obtained from *Hevea*. For these reasons, this species has not proved successful as a commercial source of rubber (Nicholls & Holland, 492–93; Burkill, II, 1409–10; Krumbiegel, 9; Schery, loc. cit.).

The rubber obtained has a good appearance, but the resin content (3–12%) is rather high. A sample of latex coagulum from Wynaad (Madras State) contained: caoutchouc, 92.5; resin, 4.3; and insolubles, 3.2% (Burkill, II, 1410; Budhiraja & Beri, *Indian For. Leafl.*, No. 70, 1944, 11).

The roots are large and tuberous and contain starch. The leaves, flowers, fruits and rootbark are cyanogenetic. Leaves are, however, browsed by animals; they contain a bitter principle. Flowers are a rich source of nectar for bees (Burkill, II, 1410; Wehmer, II, 691).

The seeds (wt. of single seed, *c.* 0.5 g.) have a hard woody shell. The kernels (25–45% of seed wt.) yield 35–42% of a greenish yellow drying oil (Manihot Seed Oil) with a slight bitter taste; the physico-chemical constants of the oil are as follows: sp. gr.$^{15°}$, 0.9238–0.9258; $n^{40°}$, 1.467–1.468; sap. val., 189–193; acid val., 0.6–1.7; iod. val., 135–138; R.M. val., 0.4–0.7; and unsapon. matter, 0.5–0.9%. The oil does not contain any conjugated fatty acid. It may be blended with linseed oil and used in the paint and varnish industry (Jamieson, 280–81; Eckey, 586).

M. dichotoma Ule and *M. piauhyensis* Ule are species closely related to *M. glaziovii*, grown in Botanical Gardens at Calcutta and Bangalore. The former is a slender but tall tree, with a characteristic di- or trichotomous branching. The latex obtained by tapping the trunk yields rubber of good quality. *M. piauhyensis* is a rather low tree with gnarled and spreading branches and laticiferous tap root. The seed kernels contain *c.* 48% oil with the following characteristics: sp. gr.$^{15°}$, 0.9225; $n_D^{40°}$, 1.4681; sap. val., 187.7; acid val., 1.6; iod. val., 144.4; R.M. val., 0.42; and unsapon. matter, 0.78% (Krumbiegel, 10; Schery, loc. cit.; Jamieson, 281).

Manila Hemp — *see* **Musa**

MANILKARA Adans. (*Sapotaceae*)

A genus of trees distributed in the tropics. Three species are found in India; *M. kauki*, an exotic species, has been introduced in gardens.

M. hexandra (Roxb.) Dubard syn. *Mimusops hexandra* Roxb.

D.E.P., V, 251; Fl. Br. Ind., III, 549; Kirt. & Basu, Pl. 584.

HINDI—*Khirni*; BENG.—*Khirkhejur*; MAR.—*Ranjana, rayan, raini*; GUJ.—*Rayan, khirni*; TEL.—*Manjipala, pala*; TAM.—*Palla, palai*; KAN.—*Bakula*; MAL.—*Pala*; ORIYA—*Khiri, khirakuli*.

A small to medium-sized evergreen tree with a spreading crown and straight massive bole, found in central India and the Deccan Peninsula; it is cultivated throughout the greater part of India for ornament and also for the sweet edible fruit. Bark dark grey, deeply furrowed; leaves elliptic-obovate or oblong, coriaceous; flowers solitary or in fascicles, white or pale yellow; berry ovoid or ellipsoid, *c.* 1.5–2.0 cm.

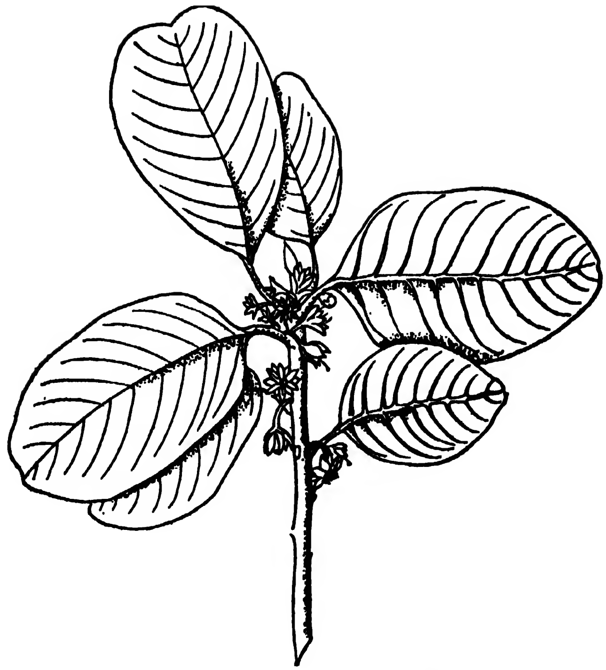


FIG. 99. MANILKARA HEXANDRA—FLOWERING BRANCH

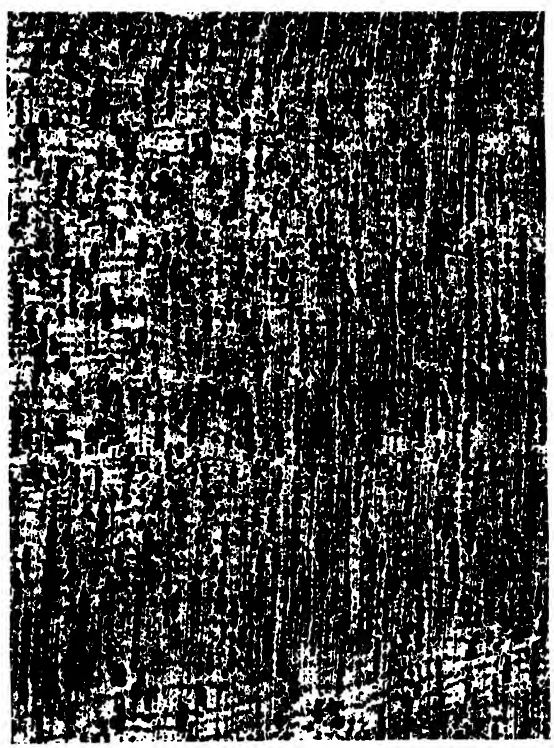
long, reddish yellow; seed 1, rarely 2, ovoid, 1.0–1.5 cm. long, reddish brown, shining.

M. hexandra is common in the dry evergreen forests of Deccan, especially on sandstone and laterite; in very dry situations it becomes stunted and even shrub-like. The tree is a light demander and natural reproduction by seed does not ordinarily take place under a dense canopy; seed fellings have, therefore, to be heavy and the best method is to girdle the trees adjoining seed bearers. Even in gaps so made, seedling growth is poor because of the irregularity of good seed years and large scale removal of edible fruits by animals and man. Young plants require low shelter, which is obtained in high forest by sparing the forest undergrowth which protects the soil and spares the fruit. The tree may be artificially propagated, like *Mimusops elengi* Linn., by seed during rains. The tree flowers from November–January and the fruits ripen from April–July (Troup, II, 639–40; Firminger, 465).

M. hexandra yields a strong dense timber. The sapwood is pale reddish to brownish white, sharply defined; heartwood red to light purplish brown with darker lines when freshly cut, turning dark vinous red to purple or purplish black on exposure, dull, smooth, fairly straight to irregular or shallowly interlocked-grained, even- and fine-textured, hard, tough, strong and heavy (sp. gr., *c.* 1.09; wt., *c.* 70 lb./cu.ft.) (Pearson & Brown, II, 683–85).

The wood is refractory to season and liable to compound end-splits and wavy surface cracks; girdling the trees 2–3 years before felling has been recommended. The timber is very durable even in contact with water, resistant to termites and needs no antiseptic treatment. It is difficult to saw, especially when seasoned. It works to a smooth surface and takes a good polish. It is commonly used for sugar mills and oil presses, piles, posts, joists and beams in construction, and agricultural implements and carts. It is suitable for mallet heads, rollers, railway keys and brake blocks, tool handles, turnery, furniture, panels, walking sticks and for such other articles where toughness and hardness are of importance (Pearson & Brown, II, 685; Lewis, 252; Kapadia, *J. Gujarat Res. Soc.*, 1954, **16**, 15, 21; Gamble, 451).

Ripe fruits of the tree are eaten fresh or dried: they are sweet but astringent. An analysis of the fruit gave the following values: moisture, 68.61; protein, 0.48; fat (ether extr.), 2.42; carbohydrates, 27.74; and mineral matter, 0.75%: calcium, 83 mg.; phosphorus, 17 mg.; iron, 0.92 mg.; carotene (as vit. A),



F.R.I., Dehra Dun. Photo: S. S. Ghosh

FIG. 100. MANILKARA HEXANDRA—TRANSVERSE SECTION OF WOOD (×10)

675 i.u. ; thiamine, 70.33 μg. ; riboflavin, 77.41 μg. ; nicotinic acid, 0.66 mg. ; and ascorbic acid, 15.67 mg./100 g. (*Rep. Dep. Nutr. Govt. Bombay*, 1957, 26).

The seeds (wt., 13.2 g./100 seeds) on extraction with ether or light petroleum yield 24.6% (47.2% in kernels) of an edible oil, known commonly as Rayan Oil ; when pressed in a *ghani*, the yield is 17.5%. The oil is pale yellow in colour with an odour reminiscent of olive oil ; pressed oil has the following characteristics: sp. gr.$^{15°}_{15°}$, 0.9150 ; $n_D^{60°}$, 1.4527 ; acid val., 1.34 ; sap. val., 191.1 ; iod. val., 65.1 ; acet. val., 5.4 ; and unsapon. matter (containing probably ergosterol), 1.02%. The fatty acid composition of the oil is as follows: palmitic, 18.9 ; stearic, 14.1 ; lignoceric, 1.1 ; oleic, 63.2 ; and linoleic acid, 2.7%. The oil deposits 'stearin' at 30° (Patel, *J. Indian Inst. Sci.*, 1924, **7**, 71).

The seeds contain a bitter saponin which is left in the cake after the extraction of oil ; a sapogenin, bassic acid ($C_{30}H_{16}O_5$, m.p. 319–24°), has been isolated. The seed cake (N, 1.5% ; P, 0.2%) has low manurial value (Patel, loc. cit. ; *Chem. Abstr.*, 1940, **34**, 6636).

The leaves are used as cattle fodder. The average composition of the leaves is as follows (dry basis): crude protein, 9.3 ; ether extr., 6.2 ; N-free extr., 53.9 ; crude fibre, 23.3 ; total ash, 7.4 ; insol. ash, 0.8 ; phosphorus (P_2O_5), 0.49 ; and calcium (CaO), 2.00% (Patel & Patel, *Indian J. agric. Sci.*, 1957, **27**, 307).

The tree yields a gum. The bark contains 10% tannin and may be used for tanning purposes. It is used in fevers and as a general tonic. The bark retards the fermentation of toddy. The seed oil is considered demulcent and emollient. *M. hexandra* has been successfully used as a root-stock for *Achras zapota ;* the methods usually employed are inarching and side grafting [Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 153 ; Howes, 1953, 281 ; Kirt. & Basu, II, 1497 ; Krumbiegel, 22 ; Naik, 424 ; Cheema *et al.*, 362, 367].

M. kauki (Linn.) Dubard syn. *Mimusops kauki* Linn.

D.E.P., V, 252 ; C.P., 627 ; Fl. Br. Ind., III, 549 ; Kirt. & Basu, Pl. 583B.

HINDI & GUJ.—*Khirni ;* MAR.—*Kauki ;* TAM.—*Palai ;* KAN.—*Hadari, hale, nemi, pale, patalli ;* MAL.—*Manilakkara, palamunippala ;* ORIYA—*Talvrynta.*

A medium-sized tree occasionally cultivated in different parts of India for ornament and its fruit. Bark greyish brown, deeply fissured ; leaves elliptic or obovate ; flowers in dense clusters near ends of branches, white ; berry ovoid-globose, orange-red, 2–3.75 cm. long, edible ; seeds 2–4.

Fruits are eaten raw or cooked ; they are sweet, slightly acidic, but rather insipid (Burkill, II, 1421).

The root and bark of the tree are considered astringent and are given in infantile diarrhoea ; they are also used for beriberi. Ground leaves are used in poultices for tumours. The seeds are considered tonic and febrifuge. They contain c. 16% of fatty oil and 1% saponin. The viscid gummy latex exuding from incisions in the bark yields an inferior type of gutta percha. *M. kauki* has been tried as a rootstock for Chinese in Malaya for making coffins (Burkill, II, 940 ; Cheema *et al.*, 367).

The wood is strong and durable. It shows no tendency to crack and can stand friction. In eastern Malaysia it is used for mills, uprights of houses and for furniture. It is reported to be valued by the Chinese in Malaya for making coffins (Burkill, II, 1421).

M. littoralis (Kurz) Dubard syn. *Mimusops littoralis* Kurz ANDAMAN BULLETWOOD

D.E.P., V, 253 ; Fl. Br. Ind., III, 549.

ANDAMANS—*Pinle-mohwa, dogola.*

A large evergreen tree, up to 36 m. in height, and 4.8 m. in girth, found in Andaman and Nicobar Islands. Bark blackish brown, thin, furrowed in old trees ; leaves elliptic or obovate, crowded towards ends of branchlets ; flowers solitary and axillary, greenish white, fragrant ; berry depressed globose, c. 3.75 cm. diam. ; seeds 5–6.

The tree is common in mixed littoral forests, forming at times a pure fringe which acts as a protective belt against the south-west monsoon (Troup, II, 640).

Andaman bulletwood is a hard, strong and heavy (sp. gr., c. 1.06 ; wt., 68 lb./cu. ft.) timber. The sapwood is pale reddish to brownish white, sharply defined ; heartwood light red with darker lines, ageing to light brownish red, with smooth greasy feel, straight- or slightly interlocked-grained, even- and fine-textured (Pearson & Brown, II, 686–87 ; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 55).

The wood is difficult to season as it is liable to develop long, deep and fine end-splits and surface

cracks; girdling the trees reduces the tendency to split. The timber is durable and does not require any antiseptic treatment. It is resistant to termites, but is attacked by teredo. The timber is difficult to work and drive nails into. It finishes well and takes a good polish. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 160; strength as a beam, 140; stiffness as a beam, 155; suitability as a post, 140; shock resisting ability, 155; retention of shape, 50; shear, 175; and hardness, 250. The wood is used for heavy construction, bridges and piles. It is suitable for mine work, agricultural implements, wheels, crushers and pounders. It may be employed as a substitute for *Lignum vitae* (*Guaiacum officinale*) for the manufacture of wooden bearings. The wood is fairly ornamental and suitable for small furniture (Pearson & Brown, II, 687–88; Gamble, 452; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, Sheet No. 14; Trotter, 1944, 195).

The bark yields a red dye. The flowers are eaten, but are said to have a sickly sweet taste (Trotter, 1940, 279; Parkinson, 196).

M. roxburghiana (Wight) Dubard syn. *Mimusops roxburghiana* Wight (Tam.—*Kanapalei*; Kan.—*Renga*) is a large tree found in South India up to an altitude of 1,500 m. The wood is reddish brown and strong; it is used for house building. The fruit of the tree contains *c.* 38% total sugars, of which 0.028% is lactose (Fl. Madras, 766; Reithel & Venkataraman, *Science*, 1956, **123**, 1083).

Manioc — *see* **Manihot**

MANISURIS Linn. (*Gramineae*)

Fl. Br. Ind., VII, 154; Fl. Madras, 1759.

A genus of annual or perennial grasses distributed in the tropics. Two or three species occur in India.

M. myurus Linn. syn. *Rottboellia myurus* Benth. (Tel.—*Nalla panuku*; Tam.—*Waritsira pillu*) is a tufted perennial with creeping stems and linear, glabrous leaves, 4.5–5.0 cm. long, common in dry and sandy places, up to 600 m., in the Deccan Peninsula. It is a good fodder grass (Rao, *J. Bombay nat. Hist. Soc.*, 1956–57, **54**, 679).

Manisuris granularis — *see* **Hackelochloa**

Manna — *see* **Alhagi, Bamboos, Eucalyptus, Fraxinus, Pinus, Tamarix**

Manna Grass — *see* **Glyceria**

MANSONIA Drummond (*Sterculiaceae*)

A small genus of trees found in Africa, India and Burma. One species is found in India.

M. dipikae Purkayastha

Purkayastha, *Indian For.*, 1947, **73**, 14.

Assam—*Lapse, badam.*

A large evergreen tree, 25–35 m. in height and up to 3 m. in girth, found in the Naga and neighbouring hills of Assam. Bark greyish white with longitudinal fissures; leaves ovate-lanceolate to obovate-oblong; flowers in paniculate cymes, white; fruit of 1–5 spreading samaras.

M. dipikae is a good timber tree. The sapwood is whitish or light yellow, somewhat lustrous; heartwood greyish brown to dark brown, often with a purplish tinge and occasional black streaks, straight-grained, medium fine- to somewhat coarse-textured, hard and heavy (wt., 40–42 lb./cu. ft.). The wood does not appear to be refractory to seasoning, but is somewhat so to pressure treatment. It is easy to work to a smooth finish and takes a good polish. In general appearance, it resembles walnut and is harder, heavier and stronger than teak. It is suitable for general carpentry, cabinet work, panelling and veneers, mathematical instruments, boot-lasts, bobbins and turnery (Chowdhury & Ghosh, *Indian For.*, 1956, **82**, 444).

MAOUTIA Wedd. (*Urticaceae*)

A small genus of shrubs distributed in South-East Asia and the Pacific. One species is found in India.

M. puya Wedd.

D.E.P., V, 177; C.P., 163; Fl. Br. Ind., V, 592.

Hindi—*Puya, pooah, poi.*

Dehra Dun & Kumaon—*Dhaul-kagshi, phurkhagsa*; Nepal & Eastern Himalayas—*Kyinki, keeang-bee, yenki.*

A shrub, up to 3 m. in height, found in the sub-Himalayan tract and outer Himalayas from Jamuna eastwards, and in Khasi hills up to an altitude of 1,600 m., chiefly in ravines and open scrubs. Bark dark grey or reddish brown, fairly smooth; leaves elliptic to ovate-oblong; flowers monoecious or dioecious, in small cymose globose heads arranged in axillary and terminal panicles; achenes ovoid, brown, hispid.

The bark yields a strong fibre, called Puya- or Nepal-hemp, resembling rhea or ramie (*Boehmeria nivea*) in general characteristics. For obtaining the fibre, the plants are cut when the seed is just being

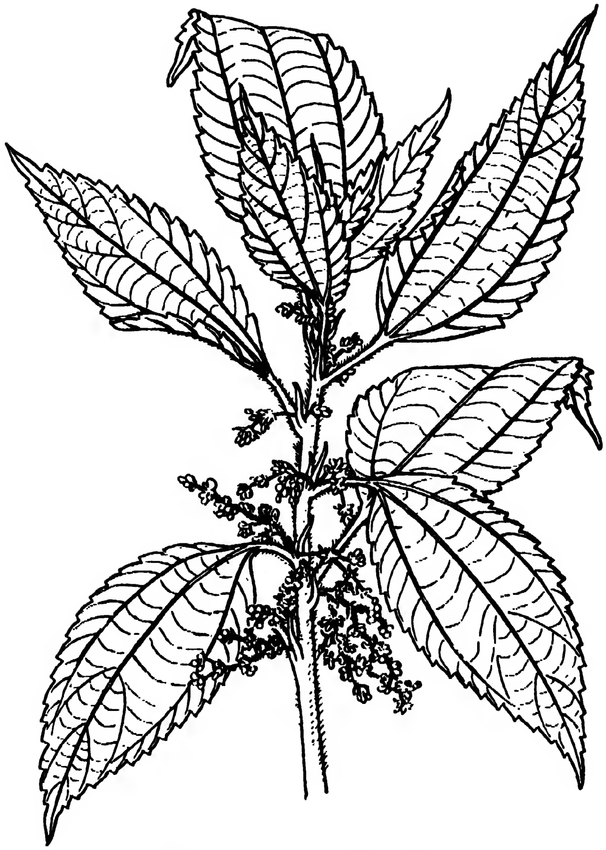


FIG. 101. MAOUTIA PUYA—FLOWERING BRANCH

formed. The bark is peeled off, dried in the sun for a few days and boiled with wood ashes for 5–6 hr. The fibre is separated by beating with wooden mallet and washed with water; it is then daubed with micaceous clay, dried and finally cleaned from clay and bark by rinsing with water. The fibre is used for fishing nets and lines, game bags, twine and ropes.

Maple — *see* **Acer**

MAPPIA Jacq. (*Icacinaceae*)

A small genus of trees and shrubs distributed chiefly in the tropics of Asia and America. Five very closely related species have been recorded from India.

M. foetida Miers= *Nothapodytes foetida* (Wight) Sleumer

Fl. Br. Ind., I, 589; Fyson, II, Pl. 81.

MAR.—*Kalgur, ghanera*; TAM.—*Arali, chorla*; KAN.—*Kodsa, hedare.*

A small or medium-sized tree, sometimes a shrub, found in the western parts of the Deccan Peninsula, North Bengal and Assam, mostly on the hills. Bark grey, wrinkled; leaves ovate-oblong, crowded towards ends of branches; flowers in cymes, yellowish, strongly foetid; drupes ovoid, 1.25–1.9 cm. long, purple; seeds 1 or 2, albuminous.

The fruit resembles jamun or jambul fruit [from *Syzygium cumini* (Linn.) Skeels] in taste and appearance. The decorticated seeds yield *c.* 48% of a yellowish brown, slightly fluorescent oil having the following characteristics: sp. gr.$^{27°}$, 0.9319; $n^{27°}$, 1.4781; acid val., 3.7; sap. val., 185.4; iod. val., 123.7; R.M. val., 0.69; Polenske val., 0.42; acet. val., 5.81; and unsapon. matter, 0.81%. The fatty acid composition of the oil is as follows: palmitic, 7.06; stearic, 17.69; oleic, 38.45; and linolenic acid, 36.80%. Sitosterol has been identified in the unsaponifiable matter [Nadkarni *et al.*, *Curr. Sci.*, 1944, **13**, 233; *J. Univ. Bombay, N.S.*, 1945–46, **14A**(19), 26].

The wood (wt., 40 lb./cu.ft.) is yellow or greyish, moderately hard, close- and silver-grained (Talbot, I, 267; Gamble, 166).

MARANTA Linn. (*Marantaceae*)

A small genus of perennial herbs, native of tropical America. Several species are ornamental. One species, *M. arundinacea*, is cultivated for its starchy rhizome which furnishes the true Arrowroot of commerce.

M. arundinacea Linn. WEST INDIAN ARROWROOT

D.E.P., V, 180; C.P., 773; Bailey, 1949, 292.

HINDI—*Tikhor*; BENG. & GUJ.—*Ararut*; MAR.—*Tavkil*; TEL. *Palaguntha*; TAM.—*Ararutțuk-kilangu, kuvamavu*; KAN.—*Tavaksha, kuvehittu*; MAL.—*Koova.*

An erect, slender, branched herb, 0.6–1.8 m. high, with large, fleshy, cylindrical obovoid rhizomes (sometimes called tubers); leaves large, ovate-oblong to ovate-lanceolate, acute; flowers white, arranged in clusters.

M. arundinacea is indigenous to tropical America. It has long been cultivated in West Indies and the chief area of cultivation is, at present, the Island of St. Vincent. Its cultivation has spread to some tropical countries, like India, Ceylon, Indo-China, Indonesia, Philippines, Queensland (Australia), Isle of Reunion and Natal (Raymond & Squires, *Trop. Sci.*, 1959, **1**, 182; Nicholls & Holland, 435; U.S.D., 1955, 1748; Cerighelli, I, 386).

The plant grows wild in some parts of India and it is sporadically cultivated in U.P., Bihar, Orissa, Bengal, Assam and Kerala. The aggregate area

under the crop in Kerala State is estimated at 500 acres. Two types of the plant are grown, blue and yellow, according to the colour of the rhizomes; the blue type gives a higher yield of starch than the yellow one. A type with a bitter rhizome of giant size is sometimes met with; yet another type, locally called *Kuzhi koova*, is of rare occurrence in Kerala; it is valued for its medicinal properties [Yegna Narayan Aiyer, *Mysore agric. J.*, 1953, **29**, 29; Haines, VI, 1150; Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 111; Information from Director of Agriculture, Kerala; Pandarakalam, *Indian Fmg, N.S.*, 1956–57, **6**(5), 43].

The plant thrives best in light, well drained loamy soils; it also grows in sandy soil. Partial shade is beneficial and the crop can be raised with benefit in mango groves or coconut plantations (Nicholls & Holland, 435; Macmillan, 293; Pandarakalam, loc. cit.).

The plant is propagated by means of rhizomes. The usual practice in Kerala is to plant small pieces of rhizome (4–7 cm. long) with buds in manured pits (7 cm. deep) on bunds, the distance between pits being 15 cm. Rhizomes are given a special smoke treatment before planting. Planting is done in May and shoots come up in about a fortnight. Irrigation is necessary during the growing period, but it is withheld a month or two previous to harvesting. The flowers are nipped off as they appear (Pandarakalam, loc. cit.; Nicholls & Holland, 437).

A banded leaf blight disease, caused by *Pellicularia filamentosa* (Pat.) Rogers, is reported to affect the plant in North Malabar. It manifests itself as a chlorotic banding of leaves with ultimate browning and rotting of foliage. Satisfactory control is obtained by spraying plants with 1% Bordeaux mixture. Spraying should be carried out every year before the monsoon, taking special care to see that both surfaces of leaves are covered (Ramakrishnan & Ramakrishnan, *Indian Phytopath.*, 1948, **1**, 129).

The rhizomes are ready for harvesting in 10–11 months after planting. Their maturity is indicated by the wilting and dying of leaves. At this stage, the plants are dug up and the rhizomes separated from the leafy stem. The yield of rhizomes varies from 4 to 7 tons per acre; yields as high as 12 tons have been recorded under favourable conditions (Nicholls & Holland, 437; Macmillan, 293; Information from Director of Agriculture, Kerala).

Harvested rhizomes are *c.* 2.5 cm. thick and 20–45 cm. long. Those of small size, as also the pointed ends of large ones containing eyes are used for planting. The bulk of the material is utilized for the production of starch. The starch content varies from 25 to 30%. Analysis of a specimen of rhizome gave the following values: moisture, 63.4; crude protein, 1.6; fat, 0.2; starch, 27.8; dextrin and sugars, 2.1; crude fibre, 3.9; and ash, 0.9% (Raymond & Squires, loc. cit.; Thorpe, I, 468).

The rhizomes are eaten boiled or roasted; they are also made into pastries. They are considered acrid and rubefacient, and used as vulnerary. In West Indies and Dominica, pounded rhizomes are used for poulticing wounds and ulcers. The leaves of the plant are locally used as packing material for meat and fish (Burkill, II, 1423–24; Brown, 1941, I, 438; Kirt. & Basu, IV, 2449; Nicholls & Holland, 435; Pandarakalam, loc. cit.).

Arrowroot starch—For the extraction of starch, the tops of rhizomes, which are poor in starch, are cut off and the rest of the material washed, peeled and pulped. Mechanical devices are employed in modern factories for pulping. The pulp is mixed with water and strained through coarse cloth to remove fibre and other impurities. The milky fluid is collected in glazed tanks and the starch allowed to settle. Resuspension and resettling are carried out several times and the deposited starch cake dried in the sun or in low temperature driers. The product is stored in well closed, moisture-proof containers. The yield of starch is *c.* 15% on the weight of the raw material (Brautlecht, 278–80; Radley, II, 18; Raymond & Squires, loc. cit.).

Arrowroot starch is available as a fine white powder, much of which coheres to form small irregular masses. It is tasteless and odourless when dry; when wet or cooked, a faint odour develops. The granules (30–50 μ) are ovoid or ellipsoid in shape with conspicuous rifts. Commercial samples contain: moisture, 12–18; starch, 80–86; and impurities (protein, mineral matter, fat and fibre), 2% (B.P.C., 1959, 56–57; Brautlecht, 280).

Starches obtained from *M. arundinacea* and *Curcuma angustifolia* (East Indian Arrowroot) are not distinguished in Indian trade. Indian standard specifications for arrowroot starch are as follows: moisture, $\ngtr$13.0%; total ash, $\ngtr$0.3%; acid insol. ash, $\ngtr$0.05%; *p*H of aq. extr., 4.5–7.0; particle size, $\ngtr$2% retained on I.S. sieve 8 (aperture 75 μ) and $\ngtr$0.5% on I.S. sieve 15 (aperture 151 μ) (IS: 1006–1957).

Arrowroot is valued as food, especially for infants, invalids and convalescents. It is employed in the

preparation of biscuits, cakes, puddings and jellies. It possesses demulcent properties and given in bowel complaints. It is also employed as a suspending agent in the preparation of barium meals and is sometimes preferred to starch in tablet making since it produces rapid disintegration. Arrowroot starch is used also as a base for face powders and in the preparation of special glues (Brautlecht, 280; U.S.D., 1955, 1748; B.P.C., 1959, 57; Raymond & Squires, loc. cit.).

The fibrous refuse, left after the extraction of starch, is used as cattle feed and manure. A sample of dried refuse contained: moisture, 12.5; ash, 2.2; fat, 0.3; fibre, 14.0; protein, 3.7; and starch, 64.0% (Nicholls & Holland, 438; Raymond & Squires, loc. cit.).

Arrowroot starch is frequently adulterated with starches of potato, sago, tapioca, sweet potato, edible canna (*Canna edulis*) and certain *Curcuma* spp. Adulterant starches can be detected by microscopic examinations (U.S.D., 1955, 1748; B.P.C., 1959, 56).

Marble — *see* **Building Stones, Limestone**

Marble Wood—*see* **Diospyros**

Margosa Tree — *see* **Azadirachta**

Marigold, French — *see* **Tagetes**

Marigold, Pot — *see* **Calendula**

MARISCUS Gaertn. (*Cyperaceae*)

Fl. Br. Ind., VI, 619.

A large genus of perennial sedges distributed in warm and warm temperate regions of the world. About 15 species occur in India.

M. albescens Gaudich.=*Cyperus pennatus* Lam. syn. *C. canescens* Vahl is a large sedge, 30-90 cm. high, with transversely lineolate leaves as long as the stem found in Sundarbans, Orissa, Konkan, western ghats and Deccan. It is considered useful as a sand binder [Prain, *Rec. bot. Surv. India*, 1903, **2**(4), 351].

M. compactus Druce=*Cyperus compactus* Retz. syn. *M. microcephalus* Presl is an erect, glabrous sedge, *c.* 120 cm. high, with linear leaves as long as the stem found throughout India up to an altitude of 900 m. It is used for making coarse mats in Tonkin (Burkill, II, 1425).

M. sieberianus Nees=*Cyperus cyperoides* (Linn.) Kuntze (Beng. - *Bara guthubi*) is a tall sedge, up to 75 cm. high, with leaves as long as the stem found more or less throughout India ascending to 1,800 m. in the Himalayas. The sedge is used as a vermifuge in Sumatra (Burkill, II, 1425).

Marjoram — *see* **Majorana, Origanum**

Markhamia — *see* **Dolichandrone**

Marking-nut Tree — *see* **Semecarpus**

Marl — *see* **Limestone**

MARLEA Roxb. (*Alangiaceae*)

A genus of trees or shrubs distributed in Africa and from South and East Asia to the Pacific. Two species are found in India. The genus *Marlea* is now considered a synonym of *Alangium*.

M. begoniifolia Roxb.=*Alangium chinense* (Lour.) Harms syn. *A. begoniifolium* (Roxb.) Baill.

D.E.P., V, 187; Fl. Br. Ind., II, 743, in part.

Beng. —*Stolpodo, bonipodo, marlia.*

Kashmir —*Prol*; Punjab - *Budanar, padlu*; Kumaon—*Tumri, garh kimu*; Nepal—*Akhane, bamanpati*; Lepcha *Falit-kung*; Assam *Marli, dieng-mylhat-lap, phagrang, bhelu.*

A small to medium-sized tree found throughout the sub-Himalayan tract, outer Himalayas and in Assam up to an altitude of 2,700 m. Bark grey or brown; leaves very variable, ovate-oblong to orbicular, up to 25 cm. long; flowers in cymes, white; fruit ovoid.

The tree occurs in moist ravines and is occasionally grown for hedges. It grows moderately fast. It is one of the recorded hosts of the Indian lac insect in Assam. The leaves of the tree are lopped for fodder. The wood (wt., 42 lb./cu. ft.) is white, soft and even-grained. It is sometimes used for house construction. It is reported to be used for furniture in Indo-China and for axe handles in Indonesia. Analysis of the wood gave the following values: lignin, 29.33; α-cellulose, 41.69; and total cellulose, 51.47% [Carter & Carter, *Rec. bot. Surv. India*, 1921, **6**(9), 403; Laurie, *Indian For. Leafl.*, No. 82, 1945, 9; Gupta, 257; Gamble, 389-90; Burkill, I, 80; West *et al.*, *Philipp. J. Sci.*, 1933, **52**, 209].

Marmots — *see* **Rats and Other Rodents**

Marrow, Vegetable — *see* **Cucurbita**

MARRUBIUM Linn. (*Labiatae*)

A small genus of annual and perennial herbs distributed in Europe, N. Africa and extra-tropical Asia. Two species occur in India.

M. vulgare Linn. HOREHOUND, HOARHOUND

D.E.P., V, 187; Fl. Br. Ind., IV, 671; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 149; Kirt. & Basu, Pl. 768.

HINDI—*Paharigandana*.

A tall, robust herbaceous perennial, 40–120 cm. high, found in Kashmir and extending westwards, at altitudes of 1,500–2,400 m. Leaves leathery or thick, orbicular or elliptic-ovate, villous, rugose or wrinkled; flowers small, white, in dense axillary whorls; nutlets very small, faintly rugose. Dried leaves and flowering tops of the plant constitute the drug Horehound, formerly used as aromatic stomachic and expectorant.

M. vulgare is a hardy plant cultivated in many parts of Europe and also in the United States of America. It thrives in almost any soil, but does best in light calcareous, rather dry, soil and sunny situations. It is propagated by seeds, cuttings and divisions. Leaves and tops are harvested just before full flowering and cured in shade in order to preserve the green colour. Horehound is considered a good bee plant (Sievers, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1999, 1948, 60; Muenscher & Rice, 97; Chittenden, II, 1009).

The drug has an agreeable, somewhat musky odour which diminishes on drying and a pungent bitter, yet pleasant, aromatic taste. It contains marrubiin (0.3–1.0%) together with other bitter principles, a volatile oil (0.05%), ursolic acid, a resin, a wax, tannin (6.5–7%), mucilage, a saponin and choline. Marrubiin ($C_{20}H_{28}O_4$, m.p. 158°) is a diterpenoid unsaturated γ-lactone, related to podocarpic acid (U.S.D., 1955, 1748; Steinmetz, II, 291; Hoppe, 555; Auster & Schaefer, Lieferung 11, No. 32, 1957; Cocker *et al.*, *Chem. & Ind.*, 1953, 1227; 1955, 773).

Horehound is a bitter tonic and possesses expectorant and diuretic properties; it is laxative in large doses. It is now rarely used by medical practitioners, but is still employed as a domestic remedy for colds, coughs and pulmonary affections in the form of infusion (Horehound Ale), syrup or candy. Preparations and extracts of horehound find their way into proprietary cough mixtures and lozenges, often in association with demulcent drugs, such as coltsfoot (*Tussilago farfara* Linn.) and liquorice (*Glycyrrhiza glabra*). An extract of fresh horehound is useful in the treatment of cardiac extrasystoles; intravenous administration produces hypotensive effect. The herb is considered useful in the treatment of cholera and prolonged fevers (Kirt. & Basu, III, 2008; U.S.D., 1955, 1748; Allport, 199–200; *Chem. Abstr.*, 1934, **28**, 531; Auster & Schaefer, loc. cit.; Youngken, 740; Chopra, 1958, 602).

MARSDENIA R. Br. (*Asclepiadaceae*)

A genus of twining, rarely erect, shrubs or undershrubs distributed chiefly in tropical and sub-tropical regions. About a dozen species are found in India.

M. roylei Wight

D.E.P., V, 188; C.P., 774; Fl. Br. Ind., IV, 35; Kirt. & Basu, Pl. 618 C.

SIMLA—*Kurung*; JAUNSAR—*Kharchu*; DEHRA DUN—*Marua-bel*; GARHWAL—*Shengori*; KUMAON & ALMORA—*Murkila, murkula*.

A large, pubescent twining shrub found throughout the warm temperate Himalayas and hills of Assam, sometimes ascending to an altitude of 2,100 m. Bark pale brown, corky, fissured; leaves ovate-cordate; flowers in cymes, orange red; follicles straight, beaked, rugose.

The plant yields a strong silky fibre used for fishing nets and lines, and for ropes. Unripe fruit is used as a cooling medicine. Roots are eaten by Lepchas. The milky latex contains small quantities of caoutchouc (Kirt. & Basu, III, 1628; Cowan & Cowan, 92).

M. tenacissima Wight & Arn.

D.E.P., V, 188; C.P., 774; Fl. Br. Ind., IV, 35.

HINDI—*Jiti, chiti, tongus*; BENG.—*Chiti, jiti*; TEL.—*Karudushtupatige*; ORIYA—*Gha*.

DEHRA DUN—*Marua-bel*; NEPAL—*Bahuni lahara, sunamarai*; LEPCHA—*Kamtiongrik*; CENTRAL INDIA—*Babal jak*.

A large, twining shrub found in the Himalayas from Kumaon to Assam up to an altitude of 1,500 m. and extending southwards to the Deccan Peninsula. Bark grey or pale brown, corky, deeply furrowed; leaves broadly ovate; flowers in much branched cymes, greenish yellow, with a somewhat offensive odour; follicles ovoid-lanceolate, longitudinally wrinkled; seeds ovate-oblong, flattened; coma c. 5 cm. long.

The stem bark yields a strong fibre, used for fishing lines, nets and cordage. To obtain the fibre, the stem is cut into sections and the bark stripped; it is then dried, steeped in water for a brief period and scraped clean of adherent material. The fibre thus obtained is elastic and resistant to alkali; it is consi-

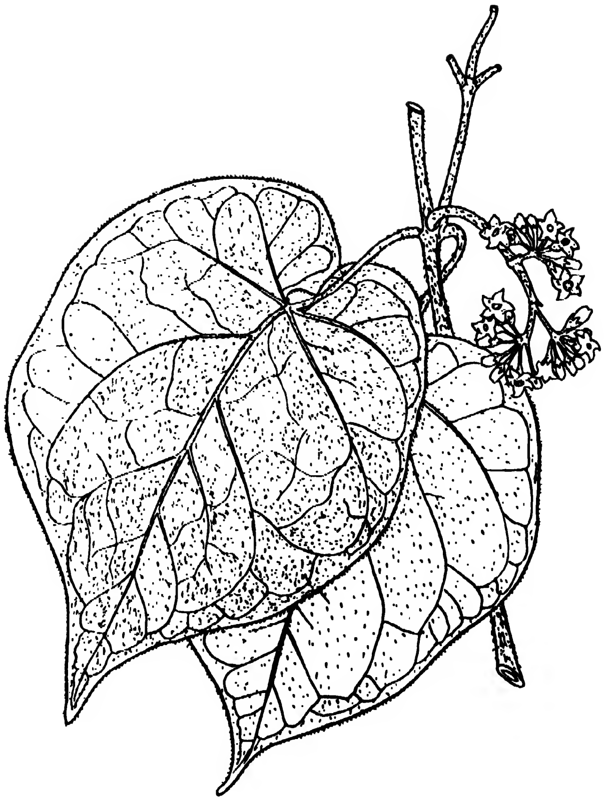


FIG. 102. MARSDENIA TENACISSIMA—FLOWERING BRANCH

dered second only to Rhea (*Boehmeria nivea*) among Indian fibres in fineness and durability. The ultimate fibres are short and for this reason, it does not lend itself to machine spinning; the fibre can be utilized only as tow. A fibre is obtained also from the seeds of the plant (Matthews, 348; *Bull. imp. Inst., Lond.*, 1903, **1**, 121; Sircar, *Misc. Bull. Indian Coun. agric. Res.*, No. 66, 1948, 64).

A milky latex is obtained from incisions made on the stem of the plant. Analysis of a sample of latex coagulum (from Madhya Pradesh) gave the following values: caoutchouc, 13.3; resins, 81.8; and insolubles, 4.9%; fresh latex contains: caoutchouc, 2.4 and water solubles, 82.1%. The root is reported to be used by Mundas as a remedy for colic. Recently it has been claimed that the roots of this plant constitute the drug White Turpeth (*safed nisoth*) of the Indian markets. The drug is a well-known purgative in the Indian medicine and according to most authors is obtained from the roots of *Operculina turpethum* (Linn.) Silva Manso syn. *Ipomea turpethum* R. Br. (Budhiraja & Beri, *Indian For. Leafl.*, No. 70, 1944, 9; Bressers, 93; Wahi & Bhattacharya, *Indian J. Pharm.*, 1960, **22**, 283; Shah *et al.*, ibid., 1960, **22**, 284).

M. tinctoria R. Br.

D.E.P., V, 190; C.P., 774; Fl. Br. Ind., IV, 34.

NEPAL *Kali lara*; NORTH BENGAL—*Riyong*; LEPCHA—*Ryom*; ASSAM—*Mei-ni-buli-likur, manri.*

A tall stout climber found in eastern Himalayas and Assam. Leaves ovate-cordate, membranous; flowers small, in clustered cymes; folicles c. 7.5 cm. long, narrow, tapering; seeds ovoid. The plant is occasionally cultivated; it is propagated from layers, slips and cuttings.

The leaves yield a dye similar to indigo from *Indigofera* spp. The bark yields a fibre. The cultivation of *M. tinctoria* for the dual purpose of dye and fibre has been suggested (Burkill, II, 1426).

The plant contains an alkaloid; the leaves are used for stomach-ache and other intestinal disorders (Chopra, 506; Burkill, II, 1426).

M. hamiltonii Wight is a sub-erect or climbing undershrub found in sub-Himalayan tracts and adjacent plains of Uttar Pradesh and Bihar. The fruit is reported to be eaten (Haines, IV, 558).

M. lucida Edgew. ex Madden is a large climber with fragrant purple flowers found in Kumaon up to an altitude of 2,500 m. and in the sub-Himalayan tracts of Uttar Pradesh. It is reported to be poisonous to man and livestock (Chopra *et al.*, 47).

Marsdenia volubilis — *see* **Wattakaka**

MARSILEA Linn. (*Marsileaceae*)

D.E.P., V, 192; Bailey, 1947, II, 2003.

A genus of aquatic or sub-aquatic ferns, widely distributed in the tropical and temperate regions of the world. About 9 species are found in India.

M. minuta Linn. (BENG.—*Susnishak*; TEL.—*Mudugo-tamara, chick-lintakura*; TAM.—*Araikeerai*; KAN.—*Chitigina soppu*; KASHMIR—*Paflu*; PUNJAB—*Tripattra, godhi*) is a herb with a creeping rhizome, quadrifoliolate leaves and bean-shaped sporocarps found throughout the greater part of India, usually at the edges of ponds and irrigation channels and as a weed in wet fields. Many of the Indian floras refer this common Indian species to *M. quadrifolia* Linn. which occurs only in Kashmir. It can be propagated by divisions of the rhizome or by spores. The stalks and leaves of the plant are eaten as pot-herb, especially in times of scarcity (Mudaliar & Rao, 24; Macmillan, 167).

MARTYNIA Linn. (*Martyniaceae*)

A monotypic genus of annual herbs, represented by *M. annua*, native of Mexico, naturalized in tropical and sub-tropical regions.

M. annua Linn. syn. *M. diandra* Glox. Devil's Claw, Tiger Claw

D.E.P., V, 192 ; Fl. Br. Ind., IV, 386 ; Fl. Malesiana, Ser. I, **4**(3), 220–21, Fig. 3.

Hindi—*Hathajori, bichu ;* Beng.—*Bagh noki ;* Mar. *Vinchu ;* Guj. -*Vichchida ;* Tel.—*Garudamukku, telukondichettu ;* Tam.—*Thelkodukkukai, puli-nagam ;* Mal.—*Puli-nakham.*

Santal -*Bag lucha ;* Mundari—*Bana sarsar.*

A herbaceous, erect, branched, clammy-pubescent annual, 90–120 cm. high, found throughout India, in waste places, rubbish heaps and along road sides. Leaves large, opposite, broadly ovate to deltoid, repand-dentate ; flowers in racemes, large, foxglove-shaped, pink and dark purple blotched with yellow inside ; fruit hard, woody, with 2 sharp recurved hooks ; seeds oblong.

The leaves of the plant are eaten in times of scarcity. They are reported to be used in epilepsy and applied to tuberculous glands of the neck ; the juice is used as a gargle for sore throat. The fruit is considered alexiteric and useful in inflammations. The leaves of the plant contain chlorogenic acid [Gammie, *Rec. bot. Surv. India*, 1902, **2**(2), 185 ; Kirt. & Basu, III, 1855 ; Chopra, 1958, 601 ; Nadkarni, I, 772 ; Wehmer, II, 1140].

The seeds of the plant on solvent extraction yield 10.35% of a pale yellow semi-drying oil with a peculiar odour. The oil has the following characteristics: sp. gr.$^{25°}$, 0.9178 ; $n^{26°}$, 1.4636 ; solidification pt., $-13°$; acid val., 4.9 ; sap. val., 198.4 ; iod. val., 118 ; Hehner val., 89 ; acet. val., 31.4 ; and unsapon. matter (allyl alcohol), 2.0% ; the refractive index is unusually low for an oil with the reported iodine value. The component fatty acids of the oil are: palmitic, 8.08 ; stearic, 11.25 ; arachidic, 1.34 ; oleic, 35.84 ; and linoleic, 32.37%. Whole fruits (from Kolhapur) on solvent extraction yield 20% of a fatty oil with an orange tinge and no characteristic odour. The oil has the following constants: sp. gr.$^{23°}$, 0.9528 ; $n^{23°}$, 1.4720 ; acid val., 15.42 ; sap. val., 195.3 ; iod. val., 75.62 ; R.M. val., 3.88 ; Polenske val., 0.78 ; acet. val., 10.79 ; and unsapon. matter, 0.86%. The refractive index is unusually high for an oil with the reported iodine value. The component fatty acids of the oil are: palmitic, 10.49 ; stearic, 8.49 ; oleic, 74.49 ; and linoleic, 6.22% [Tayal & Dutt, *Proc. nat. Acad. Sci. India*, 1939, **9**, 78 ; Rege *et al., J. Univ. Bombay, N.S.*, 1943–44, **12A**(15), 31 : Eckey, 749].

FIG. 103. MARTYNIA ANNUA—FLOWERING AND FRUITING BRANCH

MASCARENHASIA A. DC. (*Apocynaceae*)

Chittenden, III, 1256.

A small genus of trees distributed in Madagascar and East Africa. *M. elastica* K. Schum. has been introduced into India and is cultivated in gardens.

M. elastica is a slender tree, 12–15 m. high, with an upright furrowed stem, oblong leaves and small flowers in axillary or terminal cymes. It is adapted to swampy ground. It furnishes a rubber which is collected to some extent in its natural habitats and known as Mgoa, Goa or Madagascar rubber. The inner bark is c. 0.5 cm. thick and can be readily cut. It is stated, however, that the latex flows slowly and the collection of rubber is not profitable. Young trees yield very little latex. The quality of rubber is reported to be good if carefully collected. The upright trunk of the tree is used in Africa for house

construction (Krumbiegel, 13 : *Bull. imp. Inst., Lond.*, 1910, **8**, 346).

Massicot — *see* **Lead Ores**

Mast Tree — *see* **Polyalthia**

Mastic Tree — *see* **Pistacia**

MASTIXIA Blume (*Cornaceae*)

A genus of trees distributed in South-East Asia. Four species are found in India.

M. arborea C. B. Clarke*

D.E.P., V, 193 ; Fl. Br. Ind., II, 745.

TAM.—*Velichi* ; MAL.—*Mattipal.*

ASSAM—*Bolong-jigri.*

A tree, up to 30 m. in height, found in the hills of Assam and Bengal and in western ghats from Konkan southwards. Bark brownish, lenticellate; leaves elliptic to obovate-oblong; flowers green, in terminal pubescent panicles of cymes: drupe ovoid or ellipsoid, purplish green, *c.* 2.5 cm. long.

The wood of the tree is whitish to greyish yellow, often with a greenish tinge, somewhat lustrous, straight-grained, coarse-textured, soft and light, (wt., 30–32 lb./cu. ft.). It is suitable for boxes, packing cases, plywood and second grade pencils. The tree yields a gum having a camphoraceous odour [Bourdillon, 184 ; Chowdhury & Ghosh, *Indian For. Rec., N.S., Util.*, 1947, **4**(3), 14 ; Trotter, 1944, 217].

M. pentandra Blume is a tree closely resembling *M. arborea*, found from Konkan to Travancore up to an altitude of 300 m. The wood is greyish white, lustrous, coarse, soft and light (wt., 28 lb./cu. ft.). It is suitable for match boxes and splints (Bourdillon, 184 ; Rama Rao, 200).

M. rostrata Blume is a small tree found in the Aka hills in Assam. It yields resinous gum which is slightly aromatic (Burkill, II, 1428).

Mate — *see* **Ilex**

MATRICARIA Linn. (*Compositae*)

A genus of herbs distributed chiefly in the Mediterranean region and Asia ; a few species occur in Africa and N. America. Some of them are ornamental and medicinal. One species has been recorded from India.

* Some authors consider this species a mere geographical variant of *M. pentandra* Blume (Danser, *Blumea*, 1934–35, **1**, 46).

M. chamomilla Linn. GERMAN CHAMOMILE

D.E.P., V, 193 ; Fl. Br. Ind., III, 315 ; Kirt. & Basu, Pl. 537A.

PUNJAB—*Babuna, suteigul.*

A much-branched, aromatic, annual reported to be found in the Punjab, Himachal Pradesh and upper Gangetic plains, probably only in gardens or as an escape. Leaves 2–3 pinnatisect: segments narrowly linear ; flowerheads solitary, 1.3–2.5 cm. diam. ; flowers borne on hemispherical or conical hollow receptacles without any palae and surrounded by involucre of 2–3 rows of small imbricate bracts: ray florets 10–20, white or yellowish, later becoming reflexed, disc florets numerous, yellow, tubular ; peduncles 2.5 cm. long, dark brown or dusk greenish yellow ; achenes with 3–5 faint ribs.

The plant has been grown recently on an experimental scale at Jammu and Katra (Kashmir State) from seeds obtained from France. Seeds sown in the nursery towards the later half of September and seedlings transplanted in the field in November, produced flowerheads in March-April. About 4 oz. of seed are sufficient per acre. In U.S.A., a yield of 400 lb. of dry flowers per acre has been recorded. Two crops can be obtained in a year [Handa *et al.*, *J. sci. industr. Res.*, 1957, **16A**(5), suppl., 26 ; Information from Regional Res. Lab., Jammu ; Sievers, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1999, 1948, 32 ; Youngken, 867].

The flowerheads of the plant constitute the drug, variously known as Wild, Sweet, False, Persian, Hungarian or German Chamomile, and used as a substitute for True or Roman Chamomile (*Anthemis nobilis* Linn.). The drug is official in a number of European pharmacopoeias.

German chamomile has a pleasant aromatic odour and bitter taste. It possesses antispasmodic, expectorant, carminative, anthelmintic, sedative, diuretic and attenuant properties and is considered useful particularly in the ailments of children such as dentition troubles, stomach disorders, earache and neuralgic pains and convulsions. The drug is also prescribed in constitutional debility, flatulent colic, hysteria and intermittent fevers. A warm and strong infusion of it is emetic, while a weak infusion acts as a mild tonic and febrifuge. The drug has antiseptic and antiphlogistic properties and is used in hair washes and in the preparation of poultices for wounds and inflammations. An infusion is used as an external counter-irritant to eczema, bruises, sores and inflammations, especially in haemorrhoids. According to I.P.C. specifications, the drug should contain:

stems, $\not>$10%; other organic matter, $\not>$2%; total ash, $\not>$10%; and acid insoluble ash, $\not>$4%. The volatile oil content should not be less than 0.4% (B.P.C.). Powdered drug is yellowish brown to light olive brown, conforming to the standards of unground drug except that the volatile oil content should not be less than 0.2% (I.P.C., 146–47; B.P.C., 1949, 513; U.S.D., 1955, 1749; Wren, 82; Hocking, 137; Auster & Schaefer, Lieferung 15, No. 43, 1958; Steinmetz, I, 123).

The active constituent of the drug is a viscous volatile oil (Oil of German Chamomile); the drug contains, besides the oil, a bitter principle (3%), apigenin and its glycoside apiin, quercimeritrin, 7-methoxy coumarin, 7-hydroxy coumarin, a dioxy coumarin, salicylic acid, a resin, phytosterol, fatty acids, vitamin C and nicotinic acid. The drug owes its antiphlogistic action to chamazulene present in the oil; pro-chamazulene or matricin (a hydroxyacetoxy-guaiadienolide), the precursor of chamazulene, with comparable antiphlogistic activity, has been isolated from the flowers. Chamazulene has been used as an antihistaminic in allergic patients. The spasmolytic effect of the drug is ascribed to apigenin or to apiin and to methoxy coumarin (Auster & Schaefer, loc. cit.; Hoppe, 557; Cekan *et al.*, *Chem. & Ind.*, 1954, 604; 1956, 1234; *Chem. Abstr.*, 1952, **46**, 10459).

The oil content of the drug varies from 0.25 to 1.35% (av., 0.48%); dried flowers from Jammu contain 0.47% oil while those from Katra contain 0.17%. Freshly distilled oil is blue, but under the influence of light and air, it gradually changes to green and finally brown. It has a strong characteristic odour and a bitter aromatic flavour; it has the following characteristics: sp. gr.$^{15°}$, 0.917–0.957; acid val., 5–50; ester val., 3–39 (after acetylation, 117–155); sol. in 95% alcohol with separation of paraffins. The constituents of the oil are: chamazulene (1–15%, av. 6%) which is responsible for the blue colour of the oil, terpene hydrocarbons, sesquiterpenes including farnesene and cadinene, sesquiterpene alcohols including bisabolol, an unsaturated ketone alcohol ($C_{15}H_{24}O_2$), bisabolol oxide ($C_{15}H_{26}O_2$), methoxy coumarin (umbelliferone methyl ether), furfural and paraffins. The oil is used, though sparingly, as a flavouring agent in liqueurs, particularly of the French type. It also enters into perfume compositions, imparting pleasing and warm tonalities (Guenther, V, 439–45; Handa *et al.*, loc. cit.; *Chem. Abstr.*, 1953, **47**, 8699, 8702).

When eaten by cattle, the flowers have a deleterious effect on milk and, in some cases, the butter produced from it. The leaves of the plant are used in China as a depurative (Chopra *et al.*, 52; Caius, *J. Bombay nat. Hist. Soc.*, 1939–40, **41**, 851).

MATTHIOLA R. Br. (*Cruciferae*)

A genus of annual, biennial and perennial herbs or subshrubs distributed in western and southern Europe, central and western Asia and Africa. One species has been introduced into India and grown in gardens.

M. incana R. Br. COMMON STOCK, GILLI FLOWER

D.E.P., V, 197; Fl. Br. Ind., I, 131; Bailey, 1949, 448.

PUNJAB – *Todri lila, todri safed.*

An erect, biennial or perennial ornamental plant, 30–60 cm. high, grown in gardens at medium to high elevation. Leaves oblong-linear to oblanceolate; flowers in terminal racemes, fragrant; fruit an erect, thick, stout pod with numerous, flattened, usually narrowly winged seeds.

M. incana is indigenous to the Mediterranean region and western Europe. It is a cold season plant grown in gardens for its delightfully fragrant flowers borne in clusters of various hues ranging from white to pink, red, purple, terracotta and yellow. Propagation is done by seeds sown in sandy and light soil.

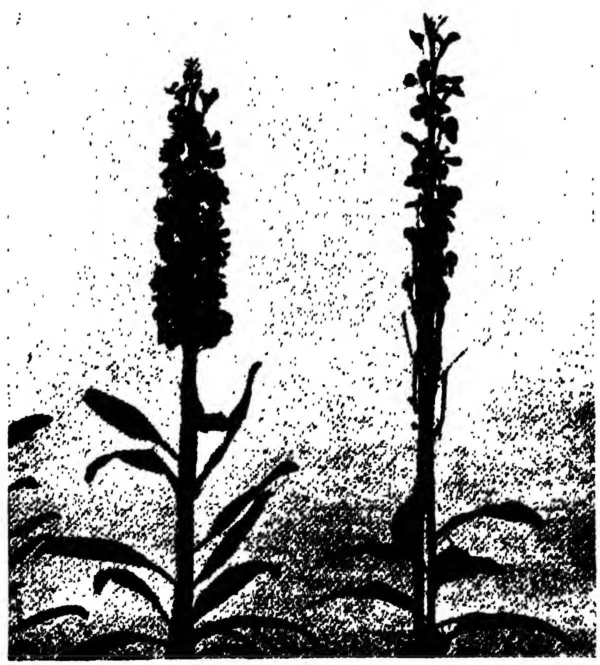


FIG. 104. MATTHIOLA INCANA—FLOWERING BRANCH

Seedlings are sparingly watered and when c. 2 in. high, transplanted 9–12 in. apart in well-prepared beds containing rich soil or are potted singly in 9-inch pots. The annuals bloom in 4–4½ months from sowing, while biennials take 7–8 months (Bailey, 1947, II, 2011; III, 3244–45; Gopalaswamiengar, 444–45; Firminger, 621).

The seeds of *M. incana* contain a fatty oil, a mucilage, colouring matter, and a volatile oil which yields methyl, isopropyl and 4-methylthiobutyl *iso*thiocyanates. The fatty oils from the seeds of yellow-, red- and white-flowered varieties have the following characteristics and fatty acid compositions: *Yellow variety* (yield, 7.9%)—sp. gr.$^{30°}$, 0.9221; *n*, 1.4301; iod. val. (Hanus), 112.3; sap. val., 184.2; acid val., 20.1; and unsapon. matter (β-sitosterol present), 0.82%; fatty acids—palmitic, 2.24; stearic, 2.86; oleic, 19.89; linoleic, 32.52; linolenic, 4.86; and erucic, 37.60%; *Red variety* (yield, 8.2%)—sp. gr.$^{30°}$, 0.9149; $n^{30°}$, 1.4332; iod. val. (Hanus), 110.2; sap. val., 186.6; acid val., 19.2; and unsapon. matter (β-sitosterol present), 0.92%; fatty acids—palmitic, 4.74; stearic, 1.61; oleic, 20.81; linoleic, 26.24; linolenic, 5.18; and erucic, 41.42%; *White variety* (yield, 10%)—sp. gr.$^{30°}$, 0.9344; $n^{30°}$, 1.3790; iod. val. (Hanus), 139.4; sap. val., 187.2; thiocyanogen val., 102.6; acid val., 2.72; ester val., 184.5; and unsapon. matter (a sitosterol present), 2.18%; fatty acids—myristic, 2.60; palmitic, 4.73; stearic, 4.37; arachidic, 2.50; lignoceric (?), 0.73; oleic, 32.17; linoleic, 21.70; linolenic, 10.70; erucic, 13.10; and resin acids, 7.40%. Two crystalline colouring matters, designated as incanin-A ($C_{18}H_{14}O_8$, m.p. 297°) and incanin-B ($C_{17}H_{14}O_7$, m.p. 278°) have been isolated from the seeds of the yellow variety. The mucilage from the seeds of the yellow variety yields, on hydrolysis, xylose, arabinose, galactose and galacturonic acid; that from the seeds of the red variety yields xylose, galactose, rhamnose and galacturonic acid (Bhakuni & Joshi, *Proc. nat. Acad. Sci. India*, 1958, **27A,** 165, 253; 1959, **28A,** 1, 190; Rahman & Khan, *J. Amer. Oil Chem. Soc.*, 1961, **38,** 281; Bhakuni, *J. sci. industr. Res.*, 1961, **20B,** 297; Jensen *et al.*, *Acta chem. scand.*, 1953, **7,** 1267; Kjaer & Gmelin, ibid., 1955, **9,** 542).

The seeds are slightly bitter and possess tonic, diuretic, expectorant and stomachic properties (Kirt. & Basu, I, 143).

Mauritius Grass — *see* **Brachiaria**

Mauritius Hemp — *see* **Furcraea**

MAZUS Lour. (*Scrophulariaceae*)

Fl. Br. Ind., IV, 259; Chatterjee & Bharadwaja, *Bull. bot. Soc. Beng.*, 1955, **9,** 146.

A small genus of herbs distributed in southern and eastern Asia, Australia and New Zealand. Eight species occur in India.

M. japonicus (Thunb.) Kuntze syn. *M. rugosus* Lour.; Hook. f. (Fl. Br. Ind.) in part, a small, prostrate or ascending, tufted annual with obovate-spathulate leaves and pale blue or white flowers, is found in damp, moist and shady situations nearly throughout India in the plains and in the hills up to 2,100 m. An infusion of the plant is given as tonic, aperitive and antifebrile (Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37,** 545).

Meadow Grass — *see* **Poa**

MECONOPSIS Vig. (*Papaveraceae*)

A genus of annual and perennial herbs distributed in northern temperate regions, mostly in Asia; a few species are found in western Europe and western North America. About 20 species occur in India, especially in the Himalayan regions.

Some of the ornamental species of *Meconopsis* have recently gained importance and are getting popular as garden plants. They are suitable for borders and rock-gardens. Propagation is done by seeds (Bailey, 1947, II, 2017).

M. napaulensis DC. syn. *M. wallichii* Hook.

D.E.P., V, 198; Fl. Br. Ind., I, 119; Kirt. & Basu, Pl. 56 & 57.

An erect, glaucescent perennial herb, laxly hairy and rarely sub-stellately pubescent, 60–180 cm. high, found in temperate Himalayas, from Nepal to Bhutan, at altitudes of 2,700–3,000 m. Leaves oblong or obovate-lanceolate, sinuate-lobed or pinnatifid; flowers fuscous-purple or pale blue, in simple or paniculate cymes; capsules elliptic-oblong, densely bristly, with many scrobiculate seeds.

The seeds of the plant yield 34.2% of a light yellow, drying oil having the following characteristics: sp. gr.$^{28°}$, 0.9320; $n^{28°}$, 1.4753; acid val., 14.2; sap. val., 182.2; iod. val., 128.7; R.M. val., 8.32; and unsapon. matter, 0.91%. The fatty acid composition of the oil is as follows: saturated, 12.0; and unsaturated (mostly linoleic and oleic), 88.0%. The oil is suitable for edible purposes and also for making paints and varnishes. The seed cake left after the extraction of oil, may be used as manure;

FIG. 105. MECONOPSIS ACULEATA—FLOWERING BRANCH

it contains: N, 3.14; lime (CaO), 1.17; and phosphoric acid (P_2O_5), 1.75%. The root has narcotic properties (Nag & Banerji, *Trans. Bose Res. Inst.*, 1934–35, **10,** 125; Kirt. & Basu, I, 133).

M. paniculata (D. Don) Prain syn. *M. nipalensis* Hook. f. & Thoms. (Fl. Br. Ind.), non DC.

D.E.P., V, 198; Fl. Br. Ind., I, 118; Kitamura in Kihara, I, Fig. 24.

An erect, stellately pubescent and laxly hairy perennial, 2 m. high, found in Nepal and Sikkim at altitudes of 3,000–3,600 m. Leaves lanceolate or oblong, sinuate-lobed or pinnatifid; flowers yellow, in racemes; capsules obovate-oblong with many small rugose seeds.

The seeds yield 32.5% of a drying oil having the following characteristics: sp. gr.^{26}, 0.9212; n^{32}, 1.4735; acid val., 32.0; sap. val., 187; iod. val., 125.2; and unsapon. matter, 1.06%. Of the total fatty acids, 18.9% are saturated and 81.1% unsaturated (mostly linoleic and oleic). The seed cake contains: N, 3.81; phosphoric acid (P_2O_5), 1.17; and lime (CaO), 0.9% (Nag & Banerji, loc. cit.).

The rootstock has a sweet taste and is reported to be eaten by herdsmen in East Nepal after peeling the outer rind. The stalk is used as salad by Sherpas. The root is regarded as a narcotic (Banerji, *J. Bombay nat. Hist. Soc.*, 1955–56, **53,** 153; Kitamura in Kihara, I, 137).

M. aculeata Royle (BLUE POPPY; PUNJAB—*Gudi, kunda, kandeli*; KASHMIR—*Gul-i-nilum*; KUMAON—*Kanda*) is a prickly herbaceous perennial found in western Himalayas, from Kumaon to Kashmir, at altitudes of 3,300–4,500 m. The root is considered poisonous; it possesses narcotic properties (Kirt. & Basu, I, 132).

MEDICAGO Linn. (*Leguminosae*)

A large genus of annual or perennial herbs, rarely shrubs, distributed in Europe, Africa and Asia. About 10 species are recorded in India including several species naturalized in tropical countries and grown as forage and pasture plants.

M. falcata Linn. YELLOW LUCERNE, SICKLE MEDICK

D.E.P., V, 199; III, 430; Fl. Br. Ind., II, 90.

A perennial herb with prostrate stems, 60–120 cm. long, found in Kashmir, Ladakh, Kunawar and Nepal at altitudes of 1,500–3,900 m. Leaves pinnately trifoliate; leaflets oblanceolate; flowers yellow, in axillary racemes; pods linear, sickle-shaped, with 5–10 seeds.

M. falcata is grown in western Himalayas for fodder but it is not raised as a regular crop; large scale collection of seeds is difficult because of the shattering of pods followed by wide dispersal of seeds. It is useful for covering banks, slopes and borders. It is frost-resistant and has been employed in breeding work. Neutral and acid saponins are reported to be present in the plant (Whyte *et al.*, 292; Chittenden, III, 1273; *Chem. Abstr.*, 1936, **30,** 4196; Ahlgren, 59).

M. hispida Gaertn. syn. *M. denticulata* Willd. CALIFORNIAN BUR CLOVER, TOOTHED BUR CLOVER, TOOTHED MEDICK

D.E.P., V, 199; III, 416; Fl. Br. Ind., II, 90.

BENG.—*Maina*.

PUNJAB—*Maina*; DELHI—*Miana, chandausi*.

An annual, semi-erect or prostrate herb found in Punjab, Kumaon, upper Gangetic plain, North Bengal and Madras, ascending to 1,500 m. in the Himalayas. Leaves pinnately trifoliate: leaflets obovate or obcordate, faintly denticulate; flowers very small, yellow, in compact heads; pod (bur) sub-globose with 2–4 loose coils, beset with spines; seeds 3–5, kidney shaped, brownish yellow.

M. hispida is a winter legume primarily adapted to regions with mild winter; it thrives in all types of soils, but prefers moist, well drained, slightly alkaline, loamy soil. It is propagated by seeds (hulled or in bur). Hulled seeds germinate readily; pre-treatment of burs in boiling water facilitates seed germination. Seeds are sown broadcast or by drill. Once established on pasture lands, the plant re-seeds itself indefinitely (McKee, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1741, 1949; Gandhi, *Indian J. agric. Sci.*, 1957, **27**, 125).

Bur clover is used as green fodder. It makes a good pasture and is relished by hogs, cattle, sheep, poultry, horses and camels. It is rarely used as hay. The burs constitute a valuable concentrated fodder for animals during the dry season. They are eaten more readily after rain when they get softened. Sheep fatten rapidly when they feed on burs but the latter get entangled in the wool and cause inconvenience to animals (Dey, *Allahabad Fmr*, 1946, **20**, 132; McKee, loc. cit.; Burkill, 1909, 21; Whyte *et al.*, 296).

Feeding on bur clover causes bloating in a few animals. In Australia, the plant has been reported to cause 'Phis' disease in sheep, horses, cattle and guinea pigs, and dermatitis of the skin due to photosensitization. The incidence of the disease is low when animals are fed on mature plants (McKee, loc. cit.; Steyn, 143–44; Connor, *Bull. Dep. sci. industr. Res. N.Z.*, No. 99, 1951, 59).

Analysis of the plant gave the following average values: dry matter, 20.8; protein, 5.1; fat, 1.7; fibre, 3.9; N-free extr., 7.8; and mineral matter, 2.3%: digestible protein, 3.9; and total digestible nutrients, 15.1%; nutritive ratio, 2.9. Copper (5.0–13.2 p.p.m.) and molybdenum (0.45–2.50 p.p.m.) occur in traces. The leaves are rich in ascorbic acid (850 mg./100 g.)

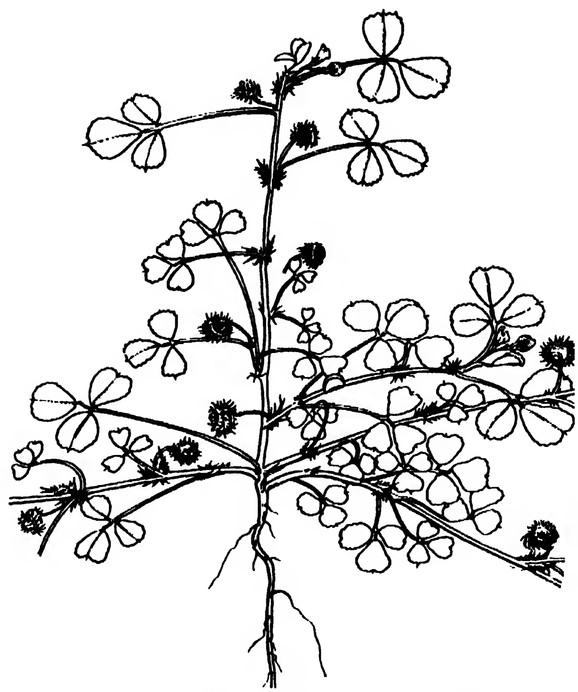


FIG. 106. MEDICAGO HISPIDA—FRUITING BRANCH

and β-carotene (51 mg./100 g. of dry material); photosensitizing agents are reported to be present (Morrison, 318, 1022; Dick *et al.*, *Aust. J. agric. Res.*, 1953, **4**, 44; Marston *et al.*, *J. Coun. sci. industr. Res. Aust.*, 1943, **16**, 113; *Chem. Abstr.*, 1954, **48**, 6079).

Analysis of seeds with burs gave the following values: crude protein, 22.9; ether extr., 3.1; N-free extr., 37.8; crude fibre, 31.6; ash, 4.7; and phosphorus (P_2O_5), 0.61% (Shapter, *J. Coun. sci. industr. Res. Aust.*, 1935, **8**, 187).

Bur clover is sometimes eaten as leafy vegetable, along with potatoes. The plant is useful for soil renovation and green manuring; it serves as a useful winter cover and prevents erosion of land (Fl. Delhi, 129; Gandhi, loc. cit.; Dey, loc. cit.; McKee, loc. cit.; Dabadghao, *Sci. & Cult.*, 1951–52, **17**, 233).

M. lupulina Linn. BLACK MEDICK, HOP CLOVER, YELLOW TREFOIL

D.E.P., V, 199; III, 416; Fl. Br. Ind., II, 90.

An annual or perennial herb found in Punjab, Kumaon, upper Gangetic plain, Bihar and North Bengal, ascending to 3,600 m. in the Himalayas. Leaves pinnately trifoliate: leaflets obovate, crenulate or denticulate; flowers small, yellow, in dense

spicate axillary racemes; pod small, kidney-shaped, spirally curved at tip, black, one-seeded; seed small, ovoid-oblong, smooth, pale buff to greenish yellow.

M. lupulina is a forage plant commonly grown in pastures. It mixes well with grasses and other clovers to make good pastures and is said to impart colour and good flavour to butter. It grows on a wide variety of soils with a good supply of lime. It is propagated by seeds sown broadcast at the rate of 10–15 lb./acre (Holland, *Kew Bull.*, 1919, 3; Hector, II, 734; Whyte *et al.*, 296).

Analysis of the plant gave the following values: moisture, 72.76; fibre, 4.29; fat, 0.70; N-free extr., 12.48; nitrogenous matter, 7.00; and ash, 2.77% (de Sornay, 288).

The plant is used in Denmark, France and Germany as green manure. Empty seed pods are fed to cattle and fowls; analysis of the material gave the following values: moisture, 10.65; protein, 15.66; fat, 0.8; fibre, 24.63; soluble carbohydrates, 40.21; and ash, 8.05%. Seeds are eaten; they are used for adulterating lucerne seeds. The plant is reported to possess lenitive properties. Aqueous extracts of the plant show anti-bacterial activity against mycobacteria (Pieters, 230, 290; de Sornay, 288; Holland, *Kew Bull.*, 1919, 3; *Chem. Abstr.*, 1930, **24,** 3604; Medsger, 129; Jacobs & Burlage, 125; Nickell, *Econ. Bot.*, 1959, **13,** 281).

M. minima Linn. LITTLE BUR CLOVER, SMALL MEDICK

Fl. Br. Ind., II, 91.

An annual herb, *c.* 15 cm. high, found in Kashmir at altitudes of 1,500–1,800 m. Leaves trifoliate: leaflets obovate-cuneate; flowers yellow; pod (bur) sub-globose, formed of 2–4 close spirals with two rows of hooked prickles.

M. minima is of some importance in pastures, but like *M. hispida*, it is undesirable in sheep pastures as burs become entangled in wool. Analysis of the plant gave the following values (dry basis): crude protein, 18.0; fat, 2.4; crude fibre, 28.1; carbohydrates, 41.2; ash, 10.3; calcium (CaO), 1.75; and phosphorus (P_2O_5), 0.71%; nutritive ratio, 2.6. The plant is suspected to cause photosensitization of sheep in Australia (Whyte *et al.*, 296; *Chem. Abstr.*, 1941, **35,** 6345; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 90).

M. sativa Linn. LUCERNE, ALFALFA

D.E.P., V, 199; III, 416, 430; C.P., 778; Fl. Br. Ind., II, 90; Lander, 159, Pl. XIX.

HINDI—*Wilayti-gawuth, lasunghas;* MAR.—*Vilayati-gavat;* GUJ.—*Vilayti-ghas;* KAN.—*Vilayati-hullu.* LADAKH—*Hol;* PUNJAB *Lusan.*

An erect, much-branched perennial herb, 0.3–1.0 m. high. Leaves pinnately trifoliate: leaflets obovate-oblong, dentate towards apex; flowers purple or violet, in dense axillary racemes; pod slightly pubescent with 2–3 spirals; seeds 6 or 8, yellow to brown, kidney-shaped.

M. sativa is a native of south-west Asia as indicated by the occurrence of wild types in the Caucasian region and in the mountainous regions of Iran, Afghanistan and adjacent localities. The cultivated form probably arose in western Persia, whence it has spread to almost all the countries of the world (Hector, II, 731; Ahlgren, 53; Piper, 348).

Lucerne exhibits considerable variation in plant form, since it is readily cross fertilized. The various types distributed in different parts of Asia and Europe, show a definite relationship between plant

FIG. 107. MEDICAGO SATIVA—FLOWERING AND FRUITING BRANCH

form and the ecological condition under which they are grown. The form of the plant changes from erect to prostrate in the direction from southern sub-tropical areas to northern and more temperate regions and also from lower to higher elevations; similarly the length of the vegetation period decreases from south to north and from lower to higher regions (Hector, II, 728–30).

Lucerne is highly valued as a legume fodder and extensively cultivated in warm temperate or cool sub-tropical regions. It is the most important fodder crop in U.S.A. where millions of acres are devoted to it. It is cultivated in India and throughout the Middle East, except in Egypt, where its cultivation is discouraged as it harbours certain cotton pests (Macmillan, 428; Cobley, 165).

Lucerne is not grown as a large scale field crop in India. It is valued as green fodder especially for horses and its cultivation is confined to military farms, rearing and remount depots and State farms; it is also grown in scattered patches by farmers for feeding milch cows [Mollison, III, 229; Roberts & Kartar Singh, 470; Mukerji, 504; Yegna Narayan Aiyer, 1950, 38; Misra, *Allahabad Fmr*, 1931, **5** (2), 12; *Mem. Dep. Agric. Madras*, No. 36, 1954, 593; Information from the Director of Agriculture, Madras].

Data relating to the acreage and production of lucerne in different States are not available. It is grown as a farm crop in Punjab (aggregated area, 13,554 acres) and western districts of Uttar Pradesh. In Maharashtra, lucerne is grown in the districts of Nasik (8,100 acres), Ahmednagar (7,900 acres), Poona (1,700 acres) and West Khandesh (700 acres). In Gujarat, the important areas of lucerne cultivation are the districts of Banaskanta (2,900 acres), Amreli (2,900 acres), Zalawad (6,352 acres), Gohilwad (4,156 acres) and Halar (3,559 acres). In Madras, it is cultivated in N. Arcot, Salem, Madurai, Tirunelveli and Coimbatore districts, and the acreage does not exceed 1,000. In West Bengal, the area under lucerne is negligibly small (Whyte, 115, 366; Information from Directors of Agriculture, Bombay, Madras and West Bengal).

Many strains of lucerne adapted to different climatic and soil conditions have been developed in various countries. In U.S.A., the cultivated varieties and strains are grouped, on the basis of flower colour, point of origin and winter hardiness, into four classes, namely, Common, Turkistan, Variegated and Non-hardy. In India, three varieties of lucerne, Persian or Arabian, Kandahar or Quetta and Meerut are grown. The Persian variety is popular; it is upright and vigorous in habit. The Kandahar variety is of trailing habit and is rarely grown. Two improved types, *No. 8* and *No. 9*, have been evolved in Punjab; both are suitable for growing under irrigation. Type *No. 9* has proved superior in sprouting ability; it recovers quickly after each cutting. In Madhya Pradesh, *strains No. 3, 5* and *7* have given high yields [Ahlgren, 58; Whyte *et al.*, 292–96; Westover, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1731, 1945; Misra, *Allahabad Fmr*, 1931, **5**(2), 12; Mollison, III, 229–30; Singh & Malik, *Indian Fmg*, 1949, **10**, 255; Saini & Malik, *Indian J. agric. Sci.*, 1947, **17**, 94; Malik, *Indian Fmg, N.S.*, 1954–55, **4**(4), 15; Whyte, 121].

CULTIVATION

Climate & Soil Lucerne is hardy and drought-resistant. It does well in the plains, as well as the hills up to an altitude of 2,400 m. It can withstand high temperatures (105–110°F.) prevailing in northern India and also adapt itself to fairly low temperatures; the degree of adaptability varies with different strains. High temperature accompanied by high humidity adversely affects the crop. An annual rainfall of 20–22 in. is optimum for lucerne, but it can survive when the rainfall is as low as 14 in.; in areas of high rainfall (40 in. or more), it cannot be grown as a perennial crop [Westover, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1722, 1941; Dutt & Pugh, 351–52; Read, *Agric. Live-Stk India*, 1936, **6**, 19; Misra, *Allahabad Fmr*, 1931, **5**(2), 12; Thompstone, *Agric. J. India*, 1909, **4**, 319].

Lucerne can be grown on a variety of soils, but does best on rich, friable, well-drained loamy soil with loose sub-soil supplied with lime. It does not stand water-logging and it fails to grow in acid soils [Misra, *Allahabad Fmr*, 1931, **5**(2), 12; Dutt & Pugh, 352].

Preparation of land & Manuring -For the cultivation of lucerne, the land should be well ploughed during the rains and brought to a friable, smooth and clean condition. Farmyard manure is applied after the rains, at the rate of 20–30 cartloads per acre, and worked thoroughly into the soil. A dressing of lime is usually applied before sowing [Thompstone, loc. cit.; Misra, *Allahabad Fmr*, 1931, **5**(2), 12; Littlewood, *Agric. Live-Stk India*, 1936, **6**, 650; Crawford, ibid., 1931, **1**, 300].

Lucerne requires adequate and timely applications of manure for good and sustained yield. Farmyard

manure is applied to the soil six weeks before sowing; additional doses (5 tons/acre) are given as top dressing after every third cutting. Castor cake (3–4 cwt./acre) may be substituted for farmyard manure. Trials at Ferozepore have shown that a dressing of 2–3 cwt. of superphosphate per acre annually or 5 cwt. in alternate years improves yield. Ammonium phosphate also gives good results. Any fertilizer containing phosphates, such as bone meal, fish manure, basic slag, rock phosphate or ammophose can be used [Raheja, *Indian Fmg, N.S.*, 1957–58, **7**(11), 23; Whyte, 367; Westover, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1722, 1941; Dabadghao, *Indian Fmg, N.S.*, 1952–53, **2**(8), 8; Roberts & Kartar Singh, 470; Mollison, III, 232; Motwani, *Indian Fmg, N.S.*, 1959–60, **9**(1), 31; Crawford, loc. cit.; Jadeja & Patel, *Farmer*, 1958, **9**(2), 21].

Propagation Lucerne is propagated by seeds. Seeds have a hard coat and they should be scarified or soaked in water before sowing. Fresh seeds do not germinate as satisfactorily as seeds which are 2–3 years old. The crop is sown pure or grown in mixture with grasses or other legumes. In most parts of northern India, sowing is done during the cold weather, usually from mid-October to mid-November. In Bombay, the best time for sowing is early rains or between October and December. In S. India, sowing is done in June–July or in October [Roberts & Kartar Singh, 470; Yegna Narayan Aiyer, 1950, 39; Tothill, 357; Piper, 398; Dutt & Pugh, 351; Whyte *et al.*, 290; Davies, 203; Whyte, 367; Misra, *Allahabad Fmr*, 1931, **5**(2), 12; Littlewood, loc. cit.].

Seeds are sown broadcast or drilled in lines or on ridges 22–28 in. apart. Sowing on ridges is preferred as it helps in keeping the field free from weeds. When sown broadcast, the seed rate is 12–20 lb. per acre; smaller quantities (10–12 lb./acre) are required for sowing on ridges [Roberts & Kartar Singh, 470; Mollison, III, 230; Whyte, 367; Misra, *Allahabad Fmr*, 1931, **5**(2), 12; Dabadghao, loc. cit.]

Lucerne is mainly grown under irrigation, but it can be grown as an unirrigated crop in the moist soils of the Gangetic plain and in the low lying fields of Dharwar (Mysore). Frequent irrigation is necessary until the seedlings are a few inches above the ground. Subsequent irrigations are given at intervals of 10–20 days in summer and at longer intervals during winter. When the crop is well established a single copious irrigation is given. The crop requires frequent hoeing to keep the field free from weeds and to stir the soil [Whyte, 367; Watson, *Agric. J. India*, 1919, **14**, 88; *Leafl. Dep. Agric. Bombay*, No. 7, 1926; Misra, *Allahabad Fmr*, 1931, **5**(3), 4; Dutt & Pugh, 352; Dabadghao, loc. cit.; Roberts & Kartar Singh, 470; Thompstone, loc. cit.; Singh & Malik, *Indian Fmg*, 1949, **10**, 255; *Leafl. Dep. Agric. Madras*, No. 99, 1942; Littlewood, loc. cit.; Crawford, loc. cit.; *Leafl. Dep. Agric. Bombay*, No. 4, 1910].

Diseases & Pests –The diseases and pests that affect lucerne in India are not of a serious nature. Leaf spot, caused by *Pseudopeziza medicaginis* (Lib.) Sacc., has been reported in several areas. It is checked to some extent by good manuring. Affected crop should be cut and destroyed. Bacterial leaf spot [*Xanthomonas alfalfae* (Riker, Jones & Davis) Dowson] is characterised by small, round, water soaked spots. The disease is often accompanied by small brown vertical scars on the stem. Other fungal diseases affecting lucerne are: crown wart [*Urophlyctis alfalfae* (Lagerh.) Magnus], downy mildew (*Peronospora aestivalis* Syd.), rust (*Uromyces striatus* Schroet.), violet root [*Helicobasidium purpureum* (Tul.) Patouill] and mildew [*Leveillula taurica* (Lev.) Arnaud] [*Indian J. agric. Sci.*, 1950, **20**, 107; Misra, *Allahabad Fmr*, 1931, **5**(3), 4; Westover, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1722, 1941; Thompstone, loc. cit.; Patel *et al.*, *Indian Phytopath.*, 1949, **2**, 166].

Among the insect pests, *Aphis* attacks the undersurface of leaves and tender shoots. Affected plants are cut close to the ground, as soon as the pest is noticed, and the field flooded. Spraying with Incosophol, crude oil emulsion or kerosine emulsion affords effective control. Lucerne caterpillar (*Laphygma exigua* Hubn.) feeds on young leaves and causes serious damage to the crop. The pest is controlled by dusting with 5% BHC powder at the rate of 15–20 lb. per acre after cutting of crop. Leaf hopper (*Empoasca fabae*) is also reported to cause damage in some areas. Rats do considerable damage in lucerne fields by cutting the roots of plants [Misra, *Allahabad Fmr*, 1931, **5**(3), 4; Gammie & Patwardhan, *Bull. Dep. Agric. Bombay*, No. 30, 1928, 30; *Farm News Release, Indian Coun. agric. Res.*, No. 282, 1957; Saini & Malik, *Indian J. agric. Sci.*, 1947, **17**, 94].

A plant parasite, Dodder (*Cuscuta chinensis* Lam.), often kills lucerne plants. Affected plants are uprooted and burnt; if the attack is extensive the whole field should be ploughed and crops immune to dodder infection should be planted. Since dodder seeds are often mixed with lucerne seeds, care should be taken to sow only pure lucerne seeds [Misra,

Allahabad Fmr, 1931, **5**(3), 4; Gammie & Patwardhan, loc. cit.]

Harvesting & Yield—The crop is ready for cutting just before or immediately after flowering; subsequent cuttings are made at intervals of 1–1½ months. The crop is given a top dressing of manure and irrigated after each cutting. Under favourable conditions, 8–12 cuttings are obtained in a year. The yield of fodder ranges from 500–800 md. per acre per annum, and the yield is sustained for 6–7 years [Dutt & Pugh, 351–52; Singh & Malik, *Indian Fmg,* 1949, **10,** 255; Yegna Narayan Aiyer, 1950, 39 *Mem. Dep. Agric. Madras,* No. 36, 1954, 593 Mudaliar, 540; Roberts & Kartar Singh, 469–70 Malik, *Indian Fmg, N.S.,* 1954–55, **4**(4), 15; Dabadghao, loc. cit.].

Seed production—After 2–3 years of cropping, some plants are set apart for seed production and seed collection is done in April when most of the pods have turned brown. The crop is cut, tied into bundles and removed to a drying floor. Dry seeds are separated from pods by beating with sticks or by threshing. A yield of 2–3 md. of seeds per acre is usually obtained; yields as high as 8 md. per acre have been reported under favourable conditions [Malik, *Indian Fmg, N.S.,* 1954–55, **4**(4), 15; Misra, *Allahabad Fmr,* 1931, **5**(3), 4; Yegna Narayan Aiyer, 1950, 39; Roberts & Kartar Singh, 471; Dabadghao, loc. cit.; Westover, *Fmrs' Bull. U.S. Dep. Agric.,* No. 1722, 1941; Thompstone, loc. cit.].

UTILIZATION

Fodder—Lucerne is highly valued as fodder because of its high palatability and high protein and calcium contents. It is an excellent forage for horses, cattle, sheep and pigs, but excessive feeding may cause bloating. Lucerne and lucerne-grass mixtures are extensively used in U.S.A. and elsewhere for pasture, hay and silage. In India, lucerne is mostly used as green fodder for horses [Morrison, 297; Lander, 159; Misra, *Allahabad Fmr,* 1931, **5**(3), 4].

The chemical composition of lucerne is given in Table 1. Table 2 summarizes the nutritive values of green lucerne compared to other common cultivated fodders.

Lucerne, like other legumes, helps to correct the protein deficiency of cereal grains fed in rations. The essential amino acids in lucerne proteins are (g./16 g. of N): arginine, 3.5; histidine, 1.5; lysine, 4.2; tryptophan, 1.5; phenylalanine, 4.1; methionine, 1.3; threonine, 5.0; leucine, 7.9; isoleucine, 4.3; and valine, 4.9. Supplementation with methionine at

TABLE CHEMICAL COMPOSITION OF LUCERNE AND ITS PRODUCTS

	Dry matter %	Protein %	Fat	Fibre	N-free extr.	Ash %	Total dig. nutrients %	Nutritive ratio
Green feed[1,a]								
Punjab	..	19.90 (15.92)	1.81	29.51	34.68	14.10	57.79	2.6
Bihar	..	22.71 (18.17)	2.87	21.54	38.39	14.49	58.47	2.2
Bangalore	..	20.24 (16.19)	2.32	30.13	36.62	10.69	60.17	2.7
Hay[1,a]								
Bangalore	..	21.26 (16.37)	1.41	29.41	35.18	12.74	55.90	2.4
Dehydrated								
meal[2]	92.7	17.7 (12.4)	2.5	24.0	38.4	10.1	54.4	3.4
Silage, wilted[2]	36.2	6.3 (4.3)	1.4	11.4	13.9	3.2	21.5	4.0
Straw[2]	92.7	9.2 (4.7)	1.5	40.6	34.6	6.8	42.6	8.1

Figures in parentheses denote digestible protein content.
[1] Sen, *Bull. Indian Coun. agric. Res.,* No. 25, 1952, 14–15, 20 21, 26, 28.
[2] Morrison, 1000, 1036, 1002.
[a] Dry basis.

0.2% level increases the nitrogen utilization by 30%. The biological value of lucerne proteins is 60.5% and digestibility coefficient, 74% (Kuppuswamy *et al.*, 221, 229–30; Morrison, 296).

The mineral constituents present in lucerne are the following (av. values, dry basis): calcium (CaO), 2.80; phosphorus (P_2O_5), 0.74; potassium (K_2O), 4.11; sodium (Na_2O), 0.35; and magnesium (MgO), 0.44%; *trace elements*: barium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, silver, strontium, tin, titanium, vanadium and zinc (Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1952, 14; Chamberlain, *E. Afr. agric. J.*, 1955–56, **21**, 103).

Lucerne is a valuable source of vitamins A and E; it contains: β-carotene, 6.24; thiamine, 0.15; riboflavin, 0.46; niacin, 1.81; and α-tocopherol, 15.23 mg./100 g.; pantothenic acid, biotin, folic acid, choline, inositol, pyridoxine, vitamin B_{12} and vitamin K are present. Fresh lucerne is rich in vitamin C (1.78 mg./g.) but it loses 80% of the vitamin on drying. Growth regulating substances (unidentified) have been reported (Thorpe, VII, 404; Morrison, 301, 1106, 1113; Altschul, 709; Brother *et al.*, *Yearb. Agric. U.S. Dep. Agric.*, 1950 51, 345; Sahadeo *et al.*, *Proc. Indian Acad. Sci.*, 1949, **30B**, 331).

The pigments present in lucerne are β-carotene, xanthophylls and chlorophyll; xanthophylls include lutein, violaxanthin, cryptoxanthin, zeaxanthin and neoxanthin. A flavone, tricin, which inhibits the movements of smooth muscle has also been isolated. Lucerne is reported to contain citric, malic, oxalic and malonic acids; succinic, fumaric, shikimic and quinic acids are present in minor quantities (Bickoff *et al.*, *J. agric. Fd Chem.*, 1954, **2**, 563; Ferguson *et al.*, *Nature*, Lond., 1950, **166**, 116; Altschul, 709; Richardson & Hulme, *J. Sci. Fd Agric.*, 1957, **8**, 326).

Lucerne wax consists of *c.* 30% esters (chiefly myricyl stearate) and 70% paraffins (nonacosane and hentriacontane); an alcohol fraction (m.p. 85–85.5°) containing *n*-triacontanol and *n*-octacosanol has been separated from the wax. The lipids are composed of a glyceride fraction and phosphatide fraction. The component fatty acids of the former fraction are: saturated, 19.9; oleic, 31.0; linoleic, 16.9; and linolenic, 32.2%. Lucerne phosphatides are composed of lecithin (0.08%) and cephalin; the component fatty acids of the phosphatide fraction are: saturated, 13.3; oleic, 36.8; linoleic, 14.7; and linolenic, 35.2% (Warth, 236; Blair *et al.*, *Industr. Engng Chem.*, 1953, **45**, 1104; Wittcoff, 243; Jackson & Kummerow, *J. Amer. Oil Chem. Soc.*, 1949, **26**, 26; Ghatak & Krishnamurti, *J. sci. industr. Res.*, 1955, **14A**, 285).

TABLE 2—NUTRITIVE VALUES OF LUCERNE AND OTHER CULTIVATED INDIAN FODDERS*
(% dry basis)

	Protein	Sol. ash	Dig. protein	Total dig. nutrients	Nutritive ratio
Lucerne	19.90	11.73 (CaO, 2.8)	15.92	57.79	2.6
Jowar (young stage)	8.91	6.48 (CaO, 0.51)	4.20	56.07	12.4
Bajra (just before flowering)	16.25	10.90 (CaO, 1.06)	..	..	..
Oats	14.63	10.81 (CaO, 0.67)	10.50	66.70	5.4
Maize	6.74	4.99 (CaO, 0.73)	4.14	68.28	15.5
Berseem	17.35	12.00 (CaO, 2.7)	14.10	64.46	3.6
Senji	15.46	6.10 (CaO, 1.89)	12.61	64.04	4.1

*Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1952, appx I & III.

The enzymes reported in lucerne are amylase, emulsin, coagulase, peroxidase, erepsin, lipase, invertase and pectinase. Among the miscellaneous constituents present in lucerne are: toxic saponins (0.5–2% or more), an alkaloid *l*-stachydrine (0.14%) which also occurs in seeds, and two ketones, myristone ($C_{27}H_{54}O$, m.p. 74–75°) and alfalfone ($C_{21}H_{42}O$, m.p. 88.5–88.8°). A saponin mixture comprising six or more triterpenoid saponins has been extracted from dehydrated lucerne. The sapogenins obtained by the acid hydrolysis of the mixture include a mono-unsaturated dihydroxy dicarboxylic acid ($C_{30}H_{46}O_6$, m.p. 349–50°) and soyasapogenols A, B and C (m.p. 318–20°, 260° and 240–41° respectively). The saponins have pronounced action on cardiovascular, nervous and digestive systems. Symptoms of bloat have been produced in experimental animals (sheep) by oral or intravenous administration of saponin extracts (Winton & Winton, I, 655–58; Lindahl *et al.*, *Tech. Bull. U.S. Dep. Agric.*, No. 1161, 1957, 49, 62, 64–66, 80–81).

Hay—Green leafy hay prepared from plants cut at the pre-bloom stage serves as a nutritive roughage for almost all classes of livestock, particularly dairy cows, breeding stock and young growing animals. In the U.S.A., *c.* 80% of the lucerne crop is made into hay. Care is taken to avoid loss of leaves during

drying: leaves contain nearly twice as much protein as the stems. Mixing with *bhusa* serves to reduce the loss of leaves during storage. The loss of carotene during curing may be as high as 80–90% (Lander, 161–62; Hutcheson *et al.*, 313; Morrison, 300-02; Howard, *Bull. agric. Res. Inst. Pusa*, No. 150, 1923, 32; Griffiths, *Econ. Bot.*, 1949, **3,** 170).

The chemical composition of lucerne hay is given in Table 1. Hay contains the following vitamins (av. values): vitamin A, 3,013 i.u.; thiamine, 0.29 mg.; riboflavin, 1.37 mg.; niacin, 3.84 mg.; pantothenic acid, 1.78 mg.; biotin, 0.018 mg.; vitamin D, 199.5 i.u.; and vitamin E (as α-tocopherol), 2.60 mg./100 g. Hay prepared from early cut lucerne is used for dairy cattle, while that from mature crop is fed to horses, sheep and feeder cattle. Lucerne hay should be fed to dairy cows after milking, as otherwise it is liable to taint the flavour of milk (Morrison, 300, 304, 1104, 1110, 1113; Griffiths, loc. cit.).

Lucerne meal—Lucerne meal is obtained from dehydrated cuttings or hay by grinding. Dehydrated meal contains twice as much carotene as sun cured meal (Table 3) but is deficient in vitamin D. Standard lucerne meal is graded in U.S.A. on the basis of 13%, 15% and 17% protein. Lucerne leaf meal, prepared mainly from leaves, is a high grade feed containing over 20% protein (Table 1) (Morrison, 268, 303; Brother *et al.*, *Yearb. Agric. U.S. Dep. Agric.*, 1950–51, 345).

Lucerne meal is used in U.S.A. as a vitamin A supplement in rations for poultry, hogs, dairy calves and horses. In formula mashes for poultry, the addition of 2–5% meal is considered adequate. In addition to meeting vitamin A requirements, it supplies vitamin K which in poultry is necessary to prevent haemorrhagic troubles. Excessive feeding of meal may retard the growth of chicks possibly due to the presence of saponins. Cattle, dairy and hog feeds often contain 10–15% meal (Morrison, 303, 307; Peterson, *J. biol. Chem.*, 1950, **183,** 647; Altschul, 713).

Chlorophyll is extracted from ground lucerne meal on a commercial scale. Lucerne meal is a rich source of β-carotene and xanthophylls; the pigments are recovered from the meal by extraction with organic solvents and subsequent fractionation either by distribution between immiscible solvents or by chromatographic technique; phytol and sterols, potentially useful for the manufacture of sex hormones, are obtained as by-products. The residual meal is useful as a feed for stock. Lucerne may be employed as a source of vitamin C and other water-soluble vitamins (Burdick, *Econ. Bot.*, 1956, **10,** 267; Brother *et al.*, loc. cit.; Griffiths, loc. cit.).

TABLE 3—CAROTENE CONTENT OF LUCERNE PRODUCTS*

	Carotene mg./100 g.	Vitamin A activity i.u./100 g.
Green forage	6.2	10,398
Hay (av. val.)	1.8	3,013
Meal, dehydrated (17% protein)	9.3	15,579
Meal, sun-cured (17% protein)	5.3	8,818
Leaf meal, dehydrated	13.9	23,111
Silage	3.3	5,548

* Morrison, 1104, 1106.

Silage—Lucerne and mixtures of lucerne and grass make good silage. When lucerne alone is used, fermentation is assisted by the addition of molasses. A good silage is obtained by ensiling wilted cuttings. The compositions of lucerne silage and straw are given in Table 1 (Morrison, 279–82, 309, 331; Fortescue, *Agriculture, Lond.*, 1952–53, **59,** 261).

Cattle and sheep fed on lucerne as the sole source of roughage occasionally suffer from bloat or tympanitis. The disease is attributed to the presence of toxic saponins and may be prevented by feeding corn or sorghum silage along with lucerne hay or using mixed lucerne-grass pasture. Fodder cut at the flowering time and dried in the field rarely causes bloating (Chopra *et al.*, 339; Morrison, 28–29, 302; Dabadghao, loc. cit.).

Other Uses—Several methods have been developed for processing lucerne leaves into concentrates and beverages fit for human consumption; they involve the removal of odour and taste characteristic of lucerne and also the fibre. A fibre-free concentrate is prepared by steeping tender leaves in cold water, followed by grinding in a blender, extraction with water, concentration and drying under vacuum. The product so obtained (yield, 13%) contains: protein, 44.2; fibre, 0.86; ether extr., 3.55; N-free extr., 30.69; ash, 13.2; calcium, 1.90; and phosphorus, 0.52%; carotene, 110.1 mg.; ascorbic acid, 51.6 mg.; and thiamine, 1.15 mg./100 g. (Anandaswamy & Date, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1955–56, **5,** 8, 105).

Tender lucerne leaves are used as vegetable in China and parts of Central Russia. A specially processed meal is an ingredient of some proprietary infant foods in U.S.A. Lucerne leaf powder (protein, 32.7%; calcium, 1.84%) forms an excellent supple-

ment to poor rice diets, the optimum level for supplementation being 4%. As a source of calcium and phosphorus, it is comparable to milk powder (Griffiths, loc. cit.; Altschul, 713; Sur & Subrahmanyan, *Curr. Sci.*, 1954, **23**, 188; *Indian J. med. Res.*, 1955, **43**, 231; Sur, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1954–55, **4**, 159).

Lucerne can effectively replace wheat bran substrate for the culture of micro-organisms; it may be employed in the production of penicillin from *P. notatum* and amalyse from *B. subtilis*. A pectinase solution suitable for clarification of fruit juices has been separated from lucerne. A process has been worked out for extracting sugars and fermenting them to alcohol and acetic acid. Lucerne fibre has been utilized in paper manufacture (Lulla, *Research*, 1950, **3**, 581; Kertesz, 369; *Bull. cent. Fd technol. Res. Inst., Mysore*, 1952–53, **2**, 6; *Chem. Abstr.*, 1950, **44**, 10960; Griffiths, loc. cit.).

Lucerne may be grown as a cover crop and frequently increases the yield of succeeding crops. It has been used for manuring potatoes, jowar and apple and orange groves. Analysis of green material gave the following values: nitrogen, 0.85; phosphorus (P_2O_5), 0.14; potassium (K_2O), 0.72; and calcium (CaO), 0.39% (Whyte *et al.*, 290; Hutcheson *et al.*, 313; Pieters, 201; *Leafl. Dep. Agric. Bombay*, No. 7, 1926; Piper & Pieters, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1250, 1922; Rajani & Patil, *Poona agric. Coll. Mag.*, 1956–57, **47**, 128).

Lucerne is valued as bee pasturage. Analysis of lucerne honey gave the following average values: water, 16.56; invert sugar, 76.90; sucrose, 4.42; dextrin, 0.34; protein, 0.11; acid (as formic), 0.08; and ash, 0.07% (Holland, *Kew Bull.*, 1919, 3; Pellett, *Econ. Bot.*, 1948, **2**, 185; Winton & Winton, IV, 52–53, 59).

Aqueous and ethereal extracts of lucerne plant show anti-bacterial activity against Gram-negative bacteria. Powdered lucerne is used as a diluent to adjust the strength of standard *Digitalis* powder. Lucerne root is used as an adulterant of *Belladona* root (Nickell, *Econ. Bot.*, 1959, **13**, 281; Wallis, 306; Hocking, 137).

Analysis of lucerne seeds gave the following values: moisture, 11.7; protein, 33.2; fat, 10.6; N-free extr., 32.0; fibre, 8.1; and mineral matter, 4.4%. The seeds contain the alkaloids, stachydrine and *l*-homostachydrine; an unidentified base is also present. The seeds yield 8.5–11% of a drying oil (iod. val., 167.8) suitable for use in the paint and varnish industry. Lucerne seed screenings are ground and used to a limited extent in cattle feeds. The seeds contain a yellow dye. They are considered emmenagogue and lactigenic, and are used as a cooling poultice for boils (Morrison, 1042, 494; Wiehler & Marion, *Canad. J. Chem.*, 1958, **36**, 339; Jamieson, 253; Tehon, 77; Parsa, *Qualit. Plant. Mat. Veg.*, 1960, **7**, 76).

MEDINILLA Gaudich. (*Melastomataceae*)

Fl. Br. Ind., II, 546.

A large genus of shrubs or small trees distributed from western Africa to the Pacific Islands. Six species occur in India.

M. rubicunda Blume (ASSAM—*Bogitenga*), a shrub or small tree, 4.5 m. high, is found in the sub-tropical Himalayas from Sikkim eastwards in northern Bengal, Khasi and Lushai hills and Lakhimpur in Assam, at altitudes of 600–1,800 m. Leaves elliptic to lanceolate; flowers pink, in cymes; fruit an ovoid or sub-globose berry, black when ripe. The leaves are eaten cooked, and the fruits, though insipid, are edible (Fl. Assam, II, 302).

MELALEUCA Linn. (*Myrtaceae*)

A large genus of shrubs and trees native of Australia; one species extends into the tropical regions of Asia. Most species yield essential oils. *M. leucadendron* and a few other species have been introduced into India and grown in gardens.

M. leucadendron Linn. CAJUPUT TREE

D.E.P., V, 204; Fl. Br. Ind., II, 465; Kirt. & Basu, Pl. 420.

HINDI—*Kayaputi*; BENG.—*Cajuputte, cajaputi*; MAR.—*Cajuputa*; TAM.—*Kaiyappudai*.

An evergreen tree of small or moderate size with pendulous branches, sometimes attaining a height of 21 m. and a girth up to 1.5 m. Bark white, soft, spongy, peeling off in elongated papery flakes; leaves oblong-elliptic, gland-dotted; flowers small, creamy white, in more or less interrupted elongate spikes; capsules small, globular or hemispheric, woody; seeds numerous, obovoid or cuneate, very small.

M. leucadendron is indigenous to Burma, Cambodia, Thailand and Malay Peninsula to Australia. It occurs in swamps and low-lying areas and shows tolerance to saline and acid soils. It is variable; var. *minor* Duthie, the chief source of Cajuput Oil, has been introduced into India and is grown in gardens and parks as an ornamental. It is propagated by seeds

FIG. 108. MELALEUCA LEUCADENDRON—FLOWERING BRANCH

or cuttings. Seeds artificially sown do not germinate, but self-sown seedlings are common around trees (Benthall, 247 ; Chittenden, III, 1276).

Fresh leaves and terminal branchlets yield, on steam-distillation, a volatile oil, known in the trade as Oil of Cajuput (Oleum Cajuputi) and used in medicine. The fresh oil is colourless or light yellow with an agreeable camphoraceous odour and a slightly bitter aromatic taste. The commercial oil is often green due to the presence of traces of copper ; it can be rendered colourless by steam-rectification. The physico-chemical properties of the oil, as specified in the Indian Pharmacopoeia, are as follows: sp. gr.$^{20°}$, 0.913–0.926 ; $n_D^{20°}$, 1.464–1.472 ; $[\alpha]_D$, up to $-4°$; cineole, 50–65% ; sol. in 2 vol. of 80% alcohol, becoming less sol. with age. Besides cineole, the oil contains α-terpineol and its esters, *l*-α-pinene, *l*-limonene, dipentene, sesquiterpenes, azulene, sesquiterpene alcohols, valeraldehyde and benzaldehyde. The oil is sometimes cut with eucalyptus oil, fatty oils or kerosene. The oil should be preserved in well filled closed containers protected from light and stored in a cool place (Guenther, IV, 542–48 ; I.P., 419 ; B.P.C., 1959, 115).

Oil of cajuput is imported into India, chiefly from France and Netherlands. The quantities imported during 1957, 1958, 1959 and 1960–61 were respectively: 10,745 lb. (value, Rs. 48,588), 6,449 lb. (value, Rs. 23,885), 11,737 lb. (value Rs. 31,617) and 21,049 lb. (value, Rs. 54,992). The oil is used internally as an expectorant in chronic laryngitis and bronchitis, and as carminative ; overdoses cause gastro-intestinal irritation. It acts as an anthelmintic, especially against roundworms. The oil relieves toothache if introduced into hollow carious teeth. It forms a constituent of ointments and liniments and is considered efficaceous as a counter-irritant in chronic rheumatism. It is valued as a mosquito repellent and and has the advantage over citronella oil in that it is less volatile. It is also effective against lice and fleas (U.S.D., 1955, 1610 ; B.P.C., 1959, 155 ; Burkill, II, 1433 ; Kirt. & Basu, II, 1042–43 ; Guenther, IV, 548).

The wood of *M. leucadendron* is reddish brown, hard and moderately heavy (wt., 45–51 lb./cu.ft.). It is fine- and even-textured, mottled or veined and difficult to work, but can be brought to a smooth finish with sharp tools ; it is apt to split and warp in drying. The wood is strong and durable in contact with wet ground and sea water. It is used for posts, piles and ship building ; it is suitable for railway sleepers (Gamble, 351 ; Browne, 276–77 ; Burkill, II, 1431).

The bark is papery, almost impervious to water and resistant to decay. It contains a high percentage of cork cells and resembles chemically the cork of *Quercus suber* Linn., but has structural differences that preclude its use as bottle stoppers ; it can replace cork as an insulating material. The bark is used for stuffing cushions, pillows and mattresses, life belts and floats of fishing nets. It was formerly used for inscribing sacred writings (Bailey, 1947, II, 2022 ; Bryant, *Aust. J. Sci.*, 1950, **12,** 182 ; *Indian For.*, 1956, **82,** 209 ; Thomson, ibid., 1955, **81,** 715 ; Browne, 276 ; Burkill, II, 1431–32 ; Benthall, 249).

M. genistifolia Sm. is a small ornamental tree with linear-lanceolate leaves and white flowers in spikes, indigenous to Australia and grown in botanical gardens at Saharanpur and Lucknow (Parker, 246 ; Singh, *Sci. & Cult.*, 1956–57, **22,** 114).

The leaves and terminal twigs of the tree yield 0.53% of a volatile oil with a marked turpentine odour. The oil has the following characteristics: sp. gr., 0.880 ; $n^{22°}$, 1.470 ; $[\alpha]_D$, +32.7° ; sap. val., 6.8 ; insol. in 10 vol. of 80% alcohol. The oil consists mainly of *d*-pinene ; it contains cineole (c. 2%) and traces of aldehyde. The oil may be employed as a substitute for turpentine but the yield is too low to be economical [Krishna & Badhwar, *J. sci. industr. Res.*, 1950, **9A**(3), suppl., 230].

MELANOCENCHRIS Nees (*Gramineae*)

A small genus of tufted grasses found in tropical Asia and Africa. About 3 species are recorded from India.

M. jacquemontii Jaub. & Spach syn. *M. royleana* Nees; *Gracilea royleana* Hook. f.

D.E.P., III, 424; V, 207; Fl. Br. Ind., VII, 284; Blatter & McCann, 248, Pl. 165.

Hindi—*Phulsi*.

Bombay—*Guli, bedari, dongri, landgeyakussal*.

A slender, densely-tufted annual, 7.5–20 cm. high, found nearly throughout India, except in Assam. Leaves 2.5–5 cm. filiform, linear-lanceolate, grabrous or nearly so; inflorescence of fascicled spikelets, 1.2–7.5 cm. long.

The grass is fairly common in sandy, stony or barren ground and is grazed by cattle when young (Mooney, 164; Ranga Achariyar, 245; Blatter & McCann, 249).

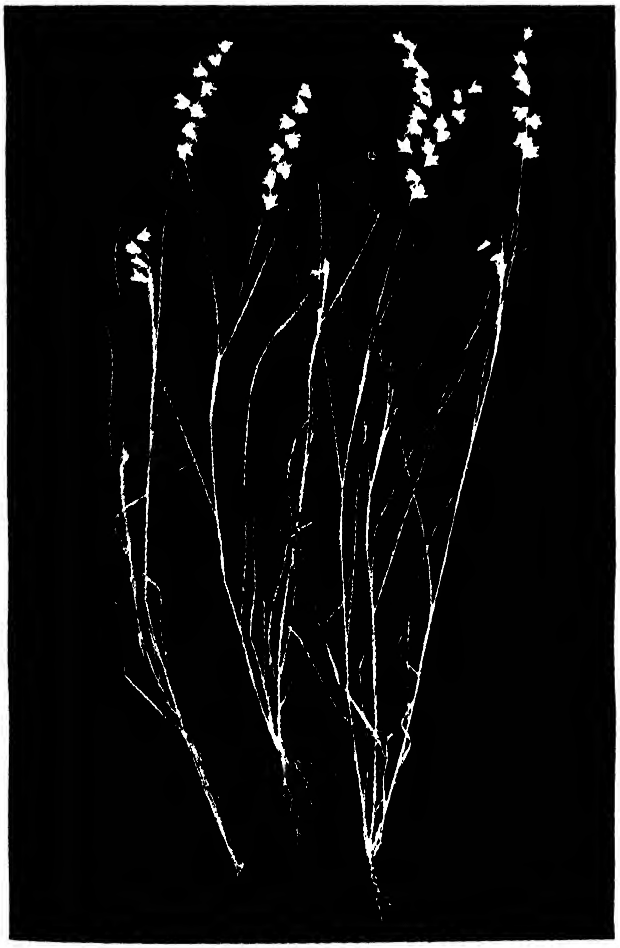


FIG. 109. MELANOCENCHRIS JACQUEMONTII—IN FLOWER

M. monoica (Rottl.) Fischer syn. *Gracilea nutans* Koenig

Fl. Br. Ind., VII, 283; Fl. Madras, 1831; Ranga Achariyar, 244, Fig. 187.

Tel.—*Achanthalagaddi, erupe nalagaddi*.

A perennial grass with culms, 15–42.5 cm. high, found in the dry localities of the eastern coast from Krishna river to S. Arcot and also in Mysore and Nilgiris up to 600 m. Leaves lanceolate, coriaceous, 1.8–2.5 cm. long; inflorescence of 4–6 closely appressed spikelets, 2.5–7.5 cm. long.

The grass grows in open, somewhat dry, loamy and laterite soils and withstands dry weather. It is relished by cattle. Analysis of the air-dry grass gave following values: moisture, 8.41; protein, 4.63; fat, 1.37; fibre, 26.52; carbohydrates, 47.0; and ash, 12.07% (Jacob, *Madras agric. J.*, 1940, **28,** 63; Ramiah, *Bull. Dep. Agric. Madras*, No. 33, 1941, 14; Tadulingam, *Yearb. Dep. Agric. Madras*, 1917, 36, 49).

MELANORRHOEA Wall. (*Anacardiaceae*)

A small genus of trees yielding a resinous lacquer, distributed in South-East Asia. *M. usitata*, the source of Burmese Lacquer, occurs in India.

M. usitata Wall. Burmese Lacquer Tree

D.E.P., V, 208; C.P., 779; Fl. Br. Ind., II, 25; Kirt. & Basu, Pl. 277.

Manipur—*Kheu*.

Trade—*Thitsi*.

A large deciduous tree, up to 18 m. in height and 2.7 m. in girth, with a straight cylindrical bole up to 9 m. long, found in Manipur. Young branches villous; bark dark grey, exfoliating in small angular thin flakes; leaves oblong or obovate-cuneate; flowers in axillary, laxly cymulose, tomentose panicles, white; drupes globular, red, borne on a thick stalk subtended by enlarged, stellately spreading persistent petals.

The tree is a light demander, but appears to benefit from slight shade when young. Natural regeneration is good in areas where trees are not subjected to heavy tapping for lacquer; good seed years, however, are irregular. The fruits fall parachute-like revolving rapidly and are carried to some distance. Seeds germinate soon after falling but seedling growth is somewhat slow; they do not stand cold or frost. For artificial reproduction direct sowing or transplanting

basket plants give good results; transplanting from the nursery is somewhat risky (Troup, I, 244–45; Wright, *Indian For. Rec.*, 1919–20, **7**, 75).

A natural varnish, known as Burmese lacquer or *thitsi*, is obtained by tapping trees through V-shaped incisions in the bark. A bamboo joint closed at the outer end is chiseled and inserted into the incision to receive the exuding varnish. After about ten days, when the flow almost ceases, a second cut is made along each side of the incision and the exudation collected; the wounds are freshened up or fresh incisions made to derive further quantities of the oleoresin. As many as 40 or 50 taps may be made in one tree, extending from the base to a height of 9 m. The tapping season lasts from the middle of June to the middle of February; but maximum yields are obtained during July–October. The size and appearance of a tree are often misleading as to its *thitsi* yielding capacity. A good tree is reported to yield 2–8 kg. of oleoresin annually (Wright, loc. cit.; Barry, 142).

Freshly collected resin is a viscous, greyish liquid with an aromatic odour. It is acrid and on contact with skin, causes violent erysipelatous swellings accompanied by pain and fever. The resin is soluble in alcohol, turpentine and benzene. It resembles Japanese lacquer (from *Rhus verniciflua* Stokes), but dries rather slowly into a lustrous, hard, black mass. Mixing with gold size improves its drying properties and intensifies the colour. Analysis of two samples of resin gave the following values: urushiol (urushic acid), 86.24, 83.24; gum, 3.08, 3.52; and oil, –, 0.53%; it contains, besides urushiol, thitsiol, an unsaturated homologue of *iso*-hydrourushiol which is also present in Japanese lacquer, but in a much smaller concentration (Heaton, 301; Barry, 142).

Thitsi is widely used in Manipur, Burma and Siam as a water-proofing paint for boats, household vessels intended to hold food, paper and cloth, as size or glue for gilding and as a non-fouling and preservative paint for wood, metalware and leather. It has been used also for palm leaf inscriptions. The paint, however, takes too long, even months, to dry and requires damp cool conditions. Linseed oil may be used for thinning the lacquer and various pigments may be incorporated to obtain coloured finishes. With saw dust, bone ash and other substances, the varnish gives a cement used in glass mosaics. Burmese lacquer is adulterated with sesamum oil, oil from the fruits of *Aleurites moluccana* and oleoresins of *Dipterocarpus* spp. (Rodger, 89; U.S.D., 1955, 1732; *Indian For.*, 1924, **50**, 597).

The tree yields a hard and durable timber. The sapwood is pinkish white, narrow; heartwood dark red, sometimes with yellowish red streaks, turning much darker with age. Thitsi wood is straight- to interlocked-grained, coarse-textured, strong, elastic and heavy [sp. gr., c. 0.69; wt., 56 (44–63) lb./cu.ft.]. Reports on its seasoning behaviour are conflicting. It is said to warp and split badly; on the other hand, good specimens with little defect and no signs of warping have been obtained. Conversion of logs soon after felling is recommended. In kiln drying, the timber is apt to become horny and hard. It is easy to saw when green, but difficult when seasoned. It can be worked with little difficulty on machines and by hand tools. It finishes to a good surface, taking a beautiful lasting polish. Its chief defect is the tendency to snap under sudden strain. The data for the comparative suitability of timber, expressed as percentages of the same properties of teak, are: wt., 125; strength as a beam, 70; stiffness as a beam, 90; suitability as a post, 85; shock-resisting ability, 55; retention of shape, 80; shear, 105; and hardness, 150 [Pearson & Brown, I, 331–33; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 54, Sheet No. 13; Rodger, 61].

The timber is durable, particularly under cover. Graveyard tests indicate a natural durability of 15 years or more. The timber is resistant to white ants (Pearson & Brown, I, 333; Purushotham *et al.*, *Indian For.*, 1953, **79**, 49; Rodger, 128).

The timber is used for building purposes as posts, beams, planking, doors and windows, for furniture, bridge construction, rafters, anchor stocks, ploughs and tool handles. It is also suitable for gun stocks, railway carriages, sleepers, mine props, sheaves, block-pulleys, etc. It is regarded as a good turnery wood. It is said to yield good charcoal (Pearson & Brown, I, 333; Rodger, 61; Limaye, loc. cit.).

The oleoresin is used as an anthelmintic; it possesses a nauseous taste. Mixed with teak sawdust it is reported to be used for leprosy (Kirt. & Basu, I, 563; *Indian For.*, 1924, **50**, 597).

MELASTOMA Linn. (*Melastomataceae*)

A genus of shrubs, rarely small trees, distributed chiefly from South and East Asia to Australia and Polynesia. About 4 species occur in India.

M. malabathricum Linn. syn. *M. polyanthum* Blume; *M. normale* D. Don

D.E.P., V, 210; Fl. Br. Ind., II, 523.

Mar.—*Palore* ; Tel.—*Pattuda* ; Tam.—*Nakkukaruppan* ; Mal.—*Kalampatti* ; Kan.—*Ankerki* ; Oriya —*Gongai, koroti.*

Nepal—*Tulasi, choulisy* ; Lepcha—*Tungbram* ; Assam—*Phutuka.*

A very variable shrub, sometimes a small tree, found near water courses and moist places in the humid parts of India up to an elevation of 1,800 m. and in the Andaman Islands ; it is occasionally cultivated in gardens. Bark reddish brown, thin ; leaves lanceolate to oblong ; flowers in terminal corymbose panicles, mauve purple ; fruit broadly ovoid, truncate, pulpy within.

The leaves, flowers and fruits are eaten ; the pulp of the fruit is sweet and slightly astringent, resembling blackberry (*Rubus* spp.) in taste and flavour [Fischer, *Rec. bot. Surv. India*, 1938, **12**(2), 95 ; Burkill, II, 1439].

The fruit yields a black or purple dye ; it is stated that an ink can be prepared from it. A pink dye is obtained from the leaves and roots. The ashes of the plant are used as a dye mordant. Atlas silkworm is said to feed on the plant and yield a fine silk [Burkill, II, 1440 ; Neal, 569 ; Carter & Carter, *Rec. bot. Surv. India*, 1921, **6**(9), 401].

The plant is astringent and used in diarrhoea and dysentery and leucorrhoea. The bark and the roots are used for healing wounds and other skin diseases ; they are also employed in the preparation of gargles (Kirt. & Basu, II, 1068 ; Burkill, II, 1440).

MELIA Linn. (*Meliaceae*)

A small genus of trees, sometimes shrubs, distributed in tropical Asia and Australia. Two species occur in India.

M. azedarach Linn. Persian Lilac, Bead Tree

D.E.P., V, 221 ; I, 432 ; C.P., 780 ; Fl. Br. Ind., I, 544.

Hindi—*Bakain, drek* ; Beng.—*Mahanim, ghora nim* ; Mar.—*Pejri, Padrai* ; Guj.—*Bakam limbodo* ; Tel.—*Turaka vepa* ; Tam.—*Malai vembu* ; Mal.—*Karin vembu, sima veppu* ; Kan.—*Arebevu, hutchu bevu.*

Punjab—*Drek* ; Nepal—*Bakaina* ; Assam—*Thamaga* ; Khasi—*Dieng-jah-rasang.*

Trade—*Persian Lilac.*

A moderate-sized deciduous tree, 9–12 m. high, with a cylindrical bole c. 3.5 m. long × 1–1.2 m. girth, found growing wild in the sub-Himalayan tract up to 1,800 m. Bark dark grey with shallow

FIG. 110. MELIA AZEDARACH—FLOWERING BRANCH

longitudinal furrows ; leaves bi- or occasionally tripinnate ; leaflets ovate or lanceolate, serrate ; flowers lilac, fragrant, in axillary panicles ; fruit an ellipsoid-globose drupe with 4–5 seeds.

M. azedarach is a native of West Asia and is now naturalized throughout the warm countries. In India, it is often cultivated in the plains as an ornamental avenue tree. It bears a spreading crown and withstands a colder climate than neem (*Azadirachta indica*) ; it is sometimes grown as a shade tree in coffee and tea plantations. It flowers during the hot season and fruits ripen during the cold weather. It is well suited for afforestation purposes (Troup, I, 183 ; Krishnaswamy, 125–26 ; Burkill, II, 1441 ; Bor, 253 ; Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 161).

Under natural conditions, the plant regenerates freely from seeds during the rains. Artificial propagation is possible by direct sowing, transplanting seedlings from the nursery or by cuttings and root suckers. The plant grows fast in the early stages, the annual girth increment being 1.5–2.0 in. It coppices well up to a girth of 3 ft. The tree does not live long and needs to be replaced after c. 20 years. The tree

is prone to the attack of *Fomes senex* Nees & Mont. [Troup, I, 184–85; Chaturvedi, *Indian Fmg, N.S.*, 1956–57, **6**(6), 14; Krishnaswamy, 126].

The tree yields a valuable timber. The sapwood is yellowish white; heartwood red, turning reddish brown with age, mostly straight-grained and coarse textured. It is tough, moderately hard, moderately heavy (sp. gr., 0.56; wt., 29.53 lb./cu. ft.), durable and lustrous with dry feel. It seasons well with care and does not require antiseptic treatment. It is resistant to attack by white ants. It is easy to work, turn, peel and finish. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 85; strength as a beam, 75; stiffness as a beam, 70; suitability as a post, 70; shock-resisting ability, 155; retention of shape, 60; shear, 125; and hardness, 75 (Pearson & Brown, I, 239–41; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 54, Sheet No. 13).

The wood is used for toys, cigars and ammunition boxes and packing and museum cases. It is suitable for sportsware, roofing material and agricultural implements. It is useful for furniture, ornamental plywood, turnery and musical instruments. It is used also as fuelwood (calorific value, 5,043–5,176 cal.) (Pearson & Brown, I, 241; II, 1076, 1084; Troup, I, 183; Sekhar, *Indian For.*, 1955, **81**, 731; Chaturvedi, loc. cit.; Howard, 361; *Indian For.*, 1948, **74**, 279).

The tree is lopped for fodder. The leaves of *M. azedarach*, unlike those of neem, are only slightly bitter; they are occasionally eaten after boiling with vegetables. Leaves are used also as green manure [Parker, 72; Laurie, *Indian For. Leafl.*, No. 82, 1945, 3; Sanyal & Banerjee, *East. Pharm.*, 1959, **2**(16), 7; Degener, *J.N.Y. bot. Gdn*, 1945, **46**, 82; Cowan & Cowan, 32].

The leaves, bark and fruits are accredited with insect-repellent properties. Leaves are placed inside books and between folds of woollen garments to protect them against insect attack. Extracts of leaves, used in sprays, protect plants against grasshoppers and locusts. A decoction of dry leaves (2–5%) is effective against locusts; the active principle is reported to be an alkaloid soluble in hot water. A carotenoid, meliatin, present in aqueous suspensions of leaves acts as a repellent to grasshoppers. Extracts of the plant are reported to be used in Ghana (Gold Coast) for protecting cocoa beans against infestation by *Ephestia* spp. Alcohol and petroleum ether extracts of the stem bark are toxic to carpet beetle larvae (Heal *et al.*, *Lloydia*, 1950, **13**, 89; Bal *et al.*,

FIG. 111. MELIA AZEDARACH—FRUITING BRANCH

J. Sci. Club, Calcutta, 1952–53, **6**, 14; *Agric. Live-Stk India*, 1939, **9**, 286; *Chem. Abstr.*, 1946, **40**, 2922; Irvine, *Colon. Pl. Anim. Prod.*, 1955, **5**, 34).

The fruits of the plant possess an unpleasant odour and an intensely bitter nauseating taste. The bitter constituents are present exclusively in the pericarp, not in the kernel as in the case of neem fruit. An amorphous bitter principle, named bakayanin (m.p. indefinite from 85–118°) has been isolated from the pericarp; it yields on hydrolysis a crystalline neutral substance, neo-bakayanin (m.p. 224°) and an amorphous bitter acid, bakayanic acid ($C_{21}H_{34}O_4$). Bakayanin is bitter in dilutions of 1 in 10,000. The fruit contains an alkaloid azaridine, also called margosine, a brown resinous substance, a non-bitter acidic substance, a sterol and tannins. It contains glucose and starch and may be employed as a raw material for the production of alcohol. A kind of whisky is reported to be made from the fruits. The stones of fruits are used as beads in necklaces,

rosaries, etc. (Watt & Breyer-Brandwijk, 93 : Amir Chand *et al.*, *J. sci. industr. Res.*, 1948, **7B,** 69 ; *Chem. Abstr.*, 1939, **33,** 6951 ; Tschirch & Stock, II, 1756 ; Burkill, II, 1442 ; Chaturvedi, loc. cit.).

The fruits of *M. azedarach* are considered poisonous to man and animals, though sheep, goats and birds have been observed to eat the fruit without apparently any ill effect. Cases of severe poisoning, as a result of eating the fruits, have been reported ; the patients develop symptoms of colic, diarrhoea and vomiting. Symptoms of paralysis and narcosis have been produced in experimental cats, dogs and sheep by ingestion of the fruit (Burkill, II, 1442 ; Dalziel, 327 ; Chopra *et al.*, 288 ; Chopra, 1958, 364).

The seeds yield 40% of a drying oil with an agreeable odour. The oil has the following constants: d^{15}_{15}, 0.9134 ; n^{15}_{D}, 1.4691 ; sap. val., 190.8 ; iod. val., 134.7 ; acid val., 4.45 ; and unsapon. matter, 1.26%. The fatty acids of the oil are: saturated (palmitic and stearic), 11.4 ; and unsaturated (oleic and linoleic), 88.6%. The unsaponifiable matter contains phytosterol and aromatic hydrocarbons. The oil is suitable for making soaps and hair oils (Eckey, 559 ; *Chem. Abstr.*, 1933, **27,** 201, 3098 ; Burkill, 1909, 18).

Various parts of the tree are reported to possess therapeutic value. The leaf juice is considered anthelmintic, antilithic, diuretic and emmenagogue ; a decoction of the leaves is regarded as astringent and stomachic. A poultice of the flowers is applied to eruptive skin diseases and for killing lice. The fruit is used in China as febrifuge and disinfectant ; seeds are prescribed in rheumatism. A gum collected from the tree, which is similar to that obtained from neem and wood apple (*Feronia limonia*), is considered useful in spleen enlargement. An infusion of the bark is effective against ascariasis ; the active principle ($C_{[illegible]}H_{[illegible]}O_{[illegible]}$, m.p. 154°) is reported to be comparable to santonin in anthelmintic activity. The activity resides in the inner bark which is bitter but not astringent ; the outer bark is astringent and is the seat of tannins. The bark contains also the alkaloids azaridine and paraisine. Aqueous extracts of the heartwood are useful in asthma. A crystalline lactone, designated bakalactone ($C_{22}H_{26}O_{4}$, m.p. 215–16.5°), a liquid with a terpenic odour (b.p. 150–60°/0.5 mm.), a resinous material and tannins have been isolated from the heartwood (Kirt. & Basu, I, 543–44 ; Burkill, II, 1442 ; Teng, *Bot. Bull. Acad. sinica*, 1947, **1,** 237 ; *Sci. Abstr. China, biol. Sci.*, No. 2, 1958, 63 ; *Chem. Abstr.*, 1953, **47,** 3304 ; Quisumbing, 482 ; Bhola Nath, *J. sci. industr. Res.*, 1954, **13B,** 740).

M. composita Willd. syn. *M. dubia* Hiern (Fl. Br. Ind.), non Cav.

D.E.P., V, 223 ; C.P., 781 ; Fl. Br. Ind., I, 545.

MAR.—*Kuriaput* ; GUJ.—*Kadukajar* ; TEL.—*Munnatikaraka* ; TAM.—*Malai vembu* ; KAN.—*Hebbevu, karibevan* ; MAL.—*Malavembu* ; ORIYA—*Batra*.

NEPAL—*Lapsi* ; KHASI—*Dieng-ja-rasang* ; GARO *Aming-gok* ; LEPCHA—*Silot-kung*.

TRADE—*Malabar Nim Wood*.

A large tree, attaining a height of c. 20 m. with a spreading crown and a cylindrical straight bole of 9 m. length × 1.2–1.5 m. girth, found in Sikkim Himalayas, North Bengal, upper Assam, Khasi hills, hills of Orissa, N. Circars, Deccan and western ghats at altitudes of 1,500–1,800 m. Bark dark brown, exfoliating in thin, narrow strips with broad, shallow, longitudinal cracks ; leaves bi- or occasionally tri pinnate ; leaflets ovate-lanceolate to ovate-rotund, entire or crenulate ; flowers greenish white.

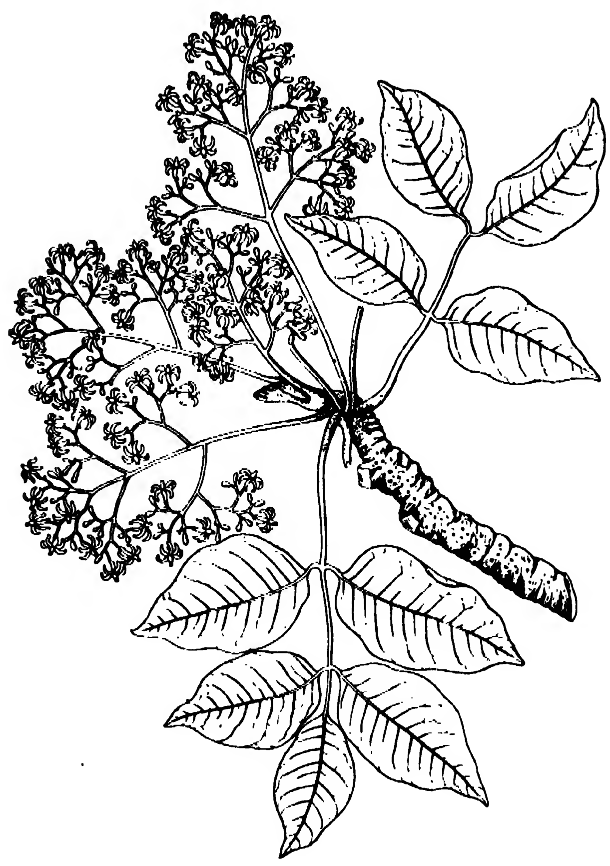
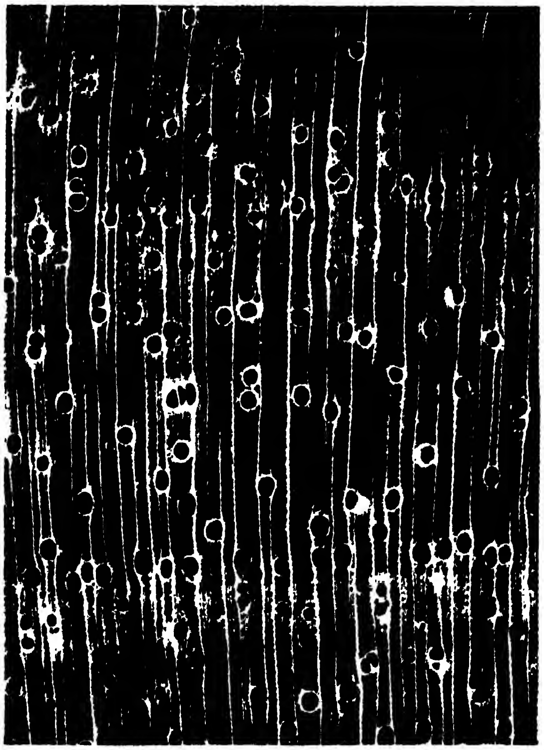


FIG. 112. MELIA COMPOSITA—FLOWERING BRANCH



F.R.I., Dehra Dun. Photo: S. S. Ghosh

FIG. 113. MELIA COMPOSITA—TRANSVERSE SECTION OF WOOD (×10)

fragrant, in dense panicles: fruit an ovoid or ellipsoid drupe with 5 or less seeds.

M. composita occurs in moist localities and tropical forests, and yields a useful timber. It is occasionally planted for ornament and makes a handsome avenue tree and a shade tree in plantations. It grows rapidly and is used for reafforestation purposes (Troup, I, 186; Burkill, II, 1443; Bor, 253).

The sapwood is greyish white; heartwood light pink to light red turning pale russet brown on ageing. It is lustrous with dry feel, very light (sp. gr., 0.33; wt., 21 lb./cu. ft.), straight-grained and coarse- and somewhat uneven-textured. The timber is not durable in exposed positions but moderately so under cover; it is not so strong and durable as neem. It seasons well if logs are converted in a green state. If left long in the log, it is liable to develop end-splitting and discolouration. The best method of dealing with the timber is to convert the logs immediately after felling and to open-stack sawn material, preferably under cover, to avoid grey stain. It saws and works easily (Pearson & Brown, I, 242–43).

The wood is used for packing cases, cigar boxes, ceiling planks, building purposes, agricultural implements, pencils, match boxes, splints and kattamarans. In Ceylon, it is employed for outriggers of boats. It is suitable for musical instruments, tea boxes and plyboard. It is a good fuelwood (calorific value, 5,043–5,176 cal.) (Pearson & Brown, I, 243; Macmillan, 96, 213; Cameron, 64; Trotter, 1944, 217; Rama Rao, 73; *Indian For.*, 1948, **74**, 279).

The fruit of the plant is bitter. It is considered anthelmintic. It gives positive tests with alkaloidal reagents (Kirt. & Basu, I, 546; Burkill, II, 1443; Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 241, 1949, 34).

Melia azadirachta — *see* **Azadirachta**

MELIANTHUS Linn. (*Sapindaceae; Melianthaceae*)

A small genus of shrubs or undershrubs native of South Africa. Two species are introduced into India.

M. comosus Vahl

Bailey, 1949, 642.

A small shrub, 1.0–1.5 m. high, introduced and grown in the Lloyd Botanic Garden, Darjeeling. Leaves pinnate: leaflets lanceolate, serrate; flowers orange inside, red spotted outside, in axillary clusters.

The plant contains 0.06% of a toxic principle. The root bark is considered to be very poisonous, but when taken in very small doses, it acts as a general tonic, especially in dyspepsia; it is said to be strongly emetic. In South Africa, a decoction of the plant is applied to slowly healing wounds and is used to relieve foot troubles: a hot bath of it is used for rheumatic limbs. A paste of the leaves is used as an external application to sores and bruises (Watt & Breyer Brandwijk, 113).

M. major Linn.

Fl. Br. Ind., I, 698; Bailey, 1949, 642; Chopra *et al.*, Fig. 55.

A wide spreading shrub, 3 m. or more high, introduced into India and found growing in cooler parts of India in Kumaon, Bhutan, Darjeeling and Ootacamund where it is almost naturalized. Leaves pinnate: leaflets ovate, deeply serrate; flowers red-brown, in terminal racemes.

M. major is suitable for rockeries and sub-tropical beddings, and is propagated by cuttings or division. The plant causes an irritant poisoning to stock, sometimes with fatal results; its toxicity is retained for a long time in dried state. In S. Africa, a decoction of the leaves is used as a lotion in the treatment

of Tinea capitis, necroses and foul ulcers, and as a gargle in sore throat and in diseases of the gums; the bruised leaves promote granulation in ulcers. The root possesses properties similar to those of *M. comosus*. The flowers are rich in honey, which is poisonous (Firminger, 585; Chittenden, III, 1280; Watt & Breyer-Brandwijk, 114; Chopra *et al.*, 307; Connor, *Bull. Dep. sci. industr. Res. N.Z.*, No. 99, 1951, 70; Macmillan, 180).

MELICA Linn. (*Gramineae*)

D.E.P., III, 436; Fl. Br. Ind., VII, 329.

A genus of perennial, erect grasses occurring in the temperate regions with about 7 or 8 species found in the western Himalayas in the drier regions from Kumaon westwards up to 3,300 m.; one species, *M. scaberrima* Hook. f., has been introduced in the Nilgiris. Of the species found in India, *M. jacquemontii* Decne syn. *M. cupani* Hook. f. (Fl. Br. Ind.) in part non Guss.; *M. ciliata* Duthie non Linn., a densely tufted, slender grass, with creeping, narrow stems, 20–45 cm. long, is reported to be a good fodder or forage grass, particularly for sheep; it is also said to be sometimes cultivated for ornamental purposes (Bailey, 1947, II, 2025).

MELILOTUS Mill. (*Leguminosae*)

A genus of annual or biennial herbs, commonly known as Sweetclovers, distributed in the temperate and warm regions of the Old World and naturalized or cultivated elsewhere. Some species are widely grown for fodder and green manure; they are useful as ground cover and soil builders. Three species are found in India.

M. indica has long been cultivated in India as a forage crop, and together with the other Indian species, *M. alba* and *M. officinalis*, it has attracted attention in other countries as a pasture plant, useful also for making hay and silage. Sweetclovers are adapted to a wide range of soil conditions, but prefer well-drained neutral or alkaline soils. The seeds are very small (250,000–275,000 seeds weigh 1 lb.) with hard testa, and need to be scarified before sowing to hasten germination. The plants have a characteristic pleasant aroma and a bitterish taste due to the presence of coumarin. They are at first disliked by stock, which, however, soon acquire a taste for them. Wide variations in coumarin content exist, not only between different species of the genus but also between plants of the same species growing in different localities. Non-bitter varieties of sweetclovers with low coumarin content have been evolved through selection.

Cattle feeding on spoiled sweetclover hay and silage develop a disease in which the clotting power of blood is diminished and animals bleed to death from minor wounds or die of internal haemorrhage. Young cattle are more susceptible to this disease than adult animals, and horses and sheep are rarely affected. The anti-coagulant principle present in spoiled hay and responsible for the disease is dicoumarol (3,3′-methylene-bis-4-hydroxycoumarin). The disease is prevented by feeding sweetclover hay along with other roughages or by feeding sweetclover hay alternately with other roughages [Krishna & Badhwar, *J. sci. industr. Res.*, 1949, **8**(2), suppl., 158; Whyte *et al.*, 297; *Plant Breed. Abstr.*, 1956, **26**, 323; Morrison, 317; Thorpe, XI, 369].

M. alba Desr. WHITE SWEETCLOVER, BOKHARA CLOVER, WHITE MELILOT

D.E.P., III, 416; Fl. Br. Ind., II, 89.

PUNJAB, U.P. & BOMBAY—*Safed senji*; DELHI—*Khandai*; BENGAL & ORISSA—*Safed banmethi*; MADHYA PRADESH—*Ranmethi*.

An erect or decumbent biennial herb, 1.0 m. or more in height, found as a winter weed of cultivation throughout India, but chiefly in the north, ascending to an altitude of 4,000 m. in the Himalayas. Leaves trifoliolate; leaflets ovate, oblong or obovate, entire or distantly serrulate; flowers in axillary racemes, white; pods ovoid, indehiscent, brown when ripe, with 1 or 2 seeds.

The plant is cultivated for fodder in Punjab and Uttar Pradesh and to a small extent in Madhya Pradesh and Coimbatore. It has gained considerable importance in U.S.A. and a number of varieties and strains have been evolved. The crop prefers well-drained alkaline soils and is sensitive to soil acidity. It comes up well under irrigated conditions, but does not give a good ratoon. Propagation is done by seeds or by cuttings; the seed rate varies from 4 to 25 lb./acre according to soil and climatic conditions. The plant is reported to be attacked by the mildew fungi, *Erysiphe polygoni* DC. and *Peronospora meliloti* Syd. (Whyte *et al.*, 297; Roberts & Kartar Singh, 462; Crosby & Kephart, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1653, 1939; Rao, *Andhra agric. J.*, 1955, **2**, 319; Robinson, 91; *Indian J. agric. Sci.*, 1950, **20**, 107).

The yield of hay from *M. alba* varies widely; yields of 0.75–1.4 tons of hay per acre during the

FIG. 114. MELILOTUS ALBA—FLOWERING AND FRUITING BRANCH

first year, and 0.75–2.7 tons/acre during the second have been reported from U.S.A. It is also suitable for ensilage. Information on the chemical composition of green feed, hay, silage and seeds is summarized in Table 1. The plant is also grown as green manure crop; analysis of the green material (from Andhra) gave the following values: nitrogen, 0.83; phosphorus (P_2O_5), 0.16; potassium (K_2O), 0.83; and calcium (CaO), 0.69%. It is also grown as a cover crop and provides a good pasture for honey bees (Morrison, 315–17; Crosby & Kephart, loc. cit.; Hollowell, *Leafl. U.S. Dep. Agric.*, No. 23, 1959; Ahlgren, 91; Rao, loc. cit.; Bailey, 1949, 583).

Feeding on white sweetclover by cattle sometimes causes colic: instances of bloating due to pasturing have been reported. The plant possesses astringent and narcotic properties, and is sometimes used as a substitute for *M. officinalis*. The fibres from the cortex are suitable for paper pulp manufacture (Nadkarni, I, 786; Crosby & Kephart, loc. cit.; Chopra, 506; Kirt. & Basu, I, 705; de Sornay, 387).

Among the exotic sweetclovers introduced into India, *M. alba* var. *annua* Coe (HUBAM SWEETCLOVER), an annual bearing white flowers is considered to be of some importance. Although the yield of green fodder or hay is much less than that from the biennial species, the plant has received attention because it grows even on poor lands and yields good silage rich in protein. Experimental cultivation at the Indian Agricultural Research Institute, New Delhi has established its utility for growing in mixture with wheat or in rotation between wheat and maize. Seeds are sown broadcast at the rate of 15–16 lb./acre before the last beaming is done on seed beds for wheat. The wheat crop is harvested in March or April, after which hubam continues to occupy the field, and yields a substantial fodder crop. With another irrigation after harvesting for fodder, a green manure crop is obtained, which is ploughed in before sowing maize. For conditions obtaining in Delhi, an early strain of wheat, *N.P. 718*, has been found suitable for growing with clover [Morrison, 315; Gandhi & Dabadghao, *Indian Fmg, N.S.*, 1955–56, **5**(12), 13; Robinson, 92].

Trial culture of wheat-hubam-maize at the Indian Agricultural Research Institute, continued over a period of three years, gave an average yield of 16.5 md. of wheat grain, 88 md. of clover fodder, 95.8 md. of green manure and 17.4 md. of maize grain per acre; wheat-maize rotation in the control plot gave an average yield of 13.7 md. of wheat and 11.8 md. of maize per acre. These results indicate that where hubam clover is included in the cultivation cycle for green manuring, the fertility of soil is maintained. In another experiment, where hubam clover crop was sown pure in October–November, a yield of 300–350 md./acre of protein-rich green fodder was obtained in three cuttings by the end of June. When grown for seed purposes, an average yield of 7.4 md. seed/acre was obtained; grown for seed as well as for fodder, the yields were 4.6 md. of seed and 73 md. of green fodder. When grown as green manure crop and ploughed in, hubam adds to the soil in one cutting c. 73 lb. of nitrogen, and after two cuttings, 59 lb. of nitrogen/acre. No substantial enrichment of soil occurs if ploughed in after three cuttings. The plant is useful also as a winter cover

TABLE 1—COMPOSITION AND NUTRITIVE VALUES OF MELILOTUS SPP.

	Total dry matter %	Prote %	Fat	N free extr. %	Fibre %	Mineral matter %	Dig. protein %	Total dig. nutrients %	Nutritive ratio
*M. alba**									
Green feed[1]	20.8	4.1	0.7	9.2	4.9	1.9	3.2	12.8	3.0
Hay (first year)[1]	91.8	16.5	2.5	39.7	24.6	8.5	11.9	50.3	
Silage[1]	28.0	4.5	0.9	10.5	9.6	2.5	3.4	15.7	3.6
Seed[1]	92.2	37.4	4.2	35.8	11.3	3.5	30.3	64.9	1.1
M. indica									
Green feed[2]	21.6	3.3	0.4	8.7	6.4	2.8	2.7	14.4	4.3
Silage[2]	29.8	2.1	0.5	9.4	14.1	3.7	0.6	15.1	23.4
Hay[3]	90.0	18.6	2.1	32.5	23.8	13.0	..	..	
Pods (dry basis)[4]	100.0	25.3	1.9	49.4	14.8	8.5	..	..	
M. officinalis									
Hay (first year)[5]	94.6		4.6	38.3	22.0	9.4			

* Analysis of the green fodder from *M. alba* (from Coimbatore) gave the following values: dry matter, 31.5; crude protein, 5.2; ether extr., 1.2; carbohydrates, 14.3; and mineral matter, 3.1% (Rao, *Andhra agric. J.*, 1955, **2**, 319).

[1] Morrison, 1022, 1006, 1038, 1046; [2] Lander, appx I; [3] de Sornay, 288; [4] Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1952, 22; [5] Ahlgren, 121.

(Gandhi & Dabadghao, loc. cit.; Dabadghao, *Sci. & Cult.*, 1951–52, **17**, 233).

Analysis of mature hubam seeds gave the following values (dry basis): crude protein, 39.4; oil, 7.6; starch, 3.0; pentosans, 8.1; total sugars (as glucose), 2.7; crude fibre, 12.9; and ash, 4.1%. The seeds contain *c.* 2% coumarin, small amounts of resins, glucosides and 2 unidentified red and yellow pigments (Clopton & Roberts, *J. Amer. Oil Chem. Soc.*, 1949, **26**, 11).

The oil obtained by petroleum ether extraction of hubam seeds is yellowish brown in colour with a pleasant odour characteristic of coumarin. It has the following constants: sp. gr.$^{25°}_{25°}$, 0.9185; $n^{25°}$, 1.4741; solidification pt., -25°; sap. val., 180.1; iod. val. (Wijs), 141.0; R.M. val., 1.4; Polenske val., 0.2; acet. val., 21.1; free fatty acids, 0.3%; saturated fatty acids, 1.5%; and unsapon. matter, 5.9%. The unsaturated fatty acids consist largely of oleic and linoleic acids. The oil is suitable for use in the paint and varnish industry. The seed meal, after the removal of toxic components (by extraction with hot alcohol), forms a useful protein supplement (protein, *c.* 47%) for cattle feeds (Clopton & Roberts, loc. cit.).

M. indica All. syn. *M. parviflora* Desf. ANNUAL YELLOW SWEETCLOVER, SMALL FLOWERED MELILOT

D.E.P., V, 225; III, 416; C.P., 1091; Fl. Br. Ind., II, 89; Kirt. & Basu, Pl. 291B.

PUNJAB, DELHI, U.P., BIHAR & BENGAL *Senji, metha, ban methi*; ORISSA—*Ban-methi, huring upu*; BOMBAY—*Van-methica, ran-methi, jhir, zir.*

An erect annual herb, up to 0.5 m. in height, found as a winter weed of cultivation almost throughout India, ascending to an altitude of 1,650 m. It is more common in North India and is cultivated for fodder, chiefly in Punjab and Uttar Pradesh. Leaves trifoliolate: leaflets obovate or oblanceolate, retuse or emarginate; flowers in slender racemes, yellow; pod ellipsoid, compressed, olive-green when ripe with 1 rarely 2 seeds; seeds brown, oblong-ellipsoid, compressed.

Senji is grown in Punjab as an irrigated cold season crop along perennial canals and on irrigated lands; it can also be cultivated on *bara* soils and in places with restricted irrigation. The chief areas of cultivation are Jullundur, Hoshiarpur, Ludhiana and Ambala districts. Data relating to the total acreage under this crop are not available; it was, however, estimated that in Punjab about three lakh acres were under *senji* cultivation. With the increasing popularity of berseem and *shaftal* (*Trifolium* spp.), the area under *senji* has lately decreased. However, in tracts where sugarcane is commonly grown after *senji*, its cultivation continues to be popular; *shaftal* and berseem cannot replace it, as they occupy the field for a much longer period. *Senji* is grown in rotation with various crops, viz. wheat, maize and rice among grain crops, and cotton, sugarcane and

FIG. 115. MELILOTUS INDICA—FLOWERING AND FRUITING BRANCH

tobacco among cash crops. It is also grown in mixture with barley and oats [Dabadghao, *Indian Fmg, N.S.*, 1952-53, **2**(8), 8; Malik, *Indian J. agric. Sci.*, 1955, **25**, 67; Yegna Narayan Aiyer, ibid., 1949, **19**, 439; Whyte *et al.*, 298; Milne *et al.*, 59; Roberts & Kartar Singh, 461-62; Read, *Agric. Live-Stk India*, 1936, **6**, 11].

Senji requires soils of medium to high fertility and is resistant to soil alkalinity. The land is ploughed 3-6 times, followed by beaming to bring it into fine condition. It is subsequently divided into 1/10 to 1/20 acre plots to facilitate irrigation. Seeds are sown in September–November, the rate per acre varying from 40 to 50 lb.; they are either scarified or softened before sowing to facilitate germination. Seeds are sown broadcast on moist or dry seed bed and covered with soil; when sown on dry beds, they are immediately irrigated. Seeds can also be sown in standing water, allowing 6-8 hours for soaking [Dabadghao, loc. cit.; Whyte *et al.*, 298; Raheja, *Indian Fmg, N.S.*, 1956–57, **6**(5), 17; Milne *et al.*, 59; Roberts & Kartar Singh, 461].

The plots are irrigated 7–10 days after sowing, and thereafter watered as required; two to three irrigations are said to be sufficient. Weeding at the early stages is beneficial. *Senji* is not usually manured since it follows manured maize or cotton in rotation. However, manuring with 1.5–2.0 md. of ammonium phosphate or a mixed fertilizer containing 20 lb. of nitrogen and 60 lb. of phosphoric acid per acre is considered beneficial. The crop is susceptible to powdery mildew (*Erysiphe polygoni* DC.) and downy mildew (*Peronospora meliloti* Syd.) (Dabadghao, loc. cit.; Roberts & Kartar Singh, 462; Raheja, loc. cit.; Mahmud & Nema, *Sci. & Cult.*, 1951–52, **17**, 473; Chona *et al.*, *Bull. Indian Coun. agric. Res.*, No. 81, 1958, 2).

Senji is harvested for fodder during February–April when the plants are in full flowering, and seed formation has already started. If harvested earlier and fed to animals, it may cause bloating. The crop is cut 2–4 times, yielding 150–250 md. of green fodder per acre. Trials at the Indian Agricultural Research Institute have indicated that *senji* crop could be grown with advantage in association with hubam clover; the total fodder yield of the mixture was higher than a pure crop of *senji*. A 3:2 mixture of hubam-*senji* is reported to be the best under Delhi conditions. A new selection, *Fo. S. I.*, has been tried in Punjab; it yields, on an average, 328 md. of fodder per acre as compared to 247.7 md./acre obtained from the local strain. A yield of 8 md. of seed/acre is reported when the crop is raised for seed purposes (Dabadghao, loc. cit.; Hall, 185; Milne *et al.*, 59; Dey, *Allahabad Fmr*, 1946, **20**, 132; Malik, loc. cit.; Roberts & Kartar Singh, 462).

Senji is used as green fodder, especially for draught cattle and milch cows. The chemical composition and nutritive value of green feed, hay, silage and pods are given in Table 1. The green fodder is particularly rich in calcium. Feeding trials have shown that it can be used as a maintenance ration for heifers; the nitrogen balance was positive (Lander & Dharmani, *Indian J. vet. Sci.*, 1936, **6**, 117).

Senji should be fed to cattle, after chopping, in admixture with *bhusa* as other dry fodder. When fed alone and in excess, it causes lethargy, tympanites and paralysis. The use of *senji* as fodder is reported to taint the milk of dairy cattle (Connor,

Bull. Dep. sci. industr. Res. N.Z., No. 99, 1951, 60; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 90).

The plant is also used as green manure. Analysis of the material gave the following values (dry basis): nitrogen, 3.36; phosphorus (P_2O_5), 0.49; potassium (K_2O), 1.53; and calcium (CaO), 2.49%. In the Punjab, the crop is recommended for improving alkaline soils; it is also useful for reclaiming saline areas and as a cover crop (Use of Leguminous Plants, 223; Pieters, 182, 214; Idnani & Chibber, *Sci. & Cult.*, 1952–53, **18**, 362; Mukerji & Agarwal, *Bull. Indian Coun. agric. Res.*, No. 68, 1950, 4; Whyte *et al.*, 298; Bailey, 1949, 583).

M. indica is used as a discutient and emollient and as fomentation, poultice or plaster for swellings. It is considered astringent and narcotic. Seeds are used in bowel complaints and infantile diarrhoea (Kirt. & Basu, I, 704; Nadkarni, I, 786).

M. officinalis Lam. YELLOW SWEETCLOVER, COMMON MELILOT

D.E.P., V, 224; Fl. Br. Ind., II, 89; Kirt. & Basu, Pl. 291A.

A tall robust biennial herb, 1.0 m. or more in height, recorded from Nubra and Ladakh at altitudes of 3,000–4,000 m.; it is also reported to be cultivated in some areas. Leaves trifoliolate: leaflets obovate, oblong or oblanceolate; flowers in lax racemes, yellowish; pods ovoid, transversely rugose, compressed, brown when ripe; seeds oval, 2.0–3.0 mm. in diam., yellowish green, smooth.

This species is cultivated for fodder in Europe and America. Analysis of the hay is given in Table 1. It is useful as honey bee pasture. The seeds are occasionally found as impurity in imported food grains and are responsible for tainting the bread. The plant contains coumarin (0.2%), melilotic acid (o-hydrocoumaric acid), coumaric acid, hydrocoumarin and resin. The flowers yield 0.013% of an essential oil containing coumarin. The fatty oil obtained from seeds (yield 7.8–8.3%) has the odour of coumarin [Schery, 418; Edlin, 86; Pingale & Bhutiani, *Indian Fmg, N.S.*, 1953–54, **3**(7), 18; Krishna & Badhwar, *J. sci. industr. Res.*, 1949, **8**(2), suppl., 158; Merck Index, 606; Heilbron & Bunbury, III, 225].

The plant is aromatic, carminative, styptic and emollient. It is reported to be used in the preparation of cigarettes for asthma. A decoction of the plant is used in lotions and enemas. The seeds are reported to be poisonous to horses (Kirt. & Basu, I, 704; Nadkarni, I, 786; Hocking, 138; U.S.D., 1955, 1750; Nayar, *J. Bombay nat. Hist. Soc.*, 1954–55, **52**, 515).

MELINIS Beauv. (*Gramineae*)

A small genus of annual or perennial grasses found mostly in tropical Africa. One species, *M. minutiflora* has been introduced into many tropical countries including India.

M. minutiflora Beauv. MOLASSES GRASS, STINK GRASS

Hitchcock, 569, fig. 820.

A viscidly hairy perennial, with a strong odour, indigenous to Africa, introduced into Assam and S. India. Culms usually decumbent, up to 1.8 m. high; leaves purple or red brown, densely hairy; panicles 10–30 cm. long, with light green or purple spikelets.

The grass grows both in moist and dry areas and can be propagated by seeds or cuttings. It is quick growing and by its spreading and rooting habit, smothers other weeds, producing a close herbage suitable for pasturing cattle. It is useful also as cover and mulch. Trials in India have shown that it yields 13–19 tons of green herbage per acre in 2 or 3 cuttings. At certain stages of its development, the grass is reported to be foul smelling and is rejected by cattle; dried grass is free from objectionable odour (*Kew Bull.*, 1922, 305; *Bull. imp. Inst., Lond.*, 1922, **20**, 300; Barua *et al.*, *Indian J. vet. Sci.*, 1951, **21**, 17; *Mem. Dep. Agric., Madras*, No. 36, 1954, 607; Dalziel, 531).

Analyses of grass cut at various stages of growth gave the following values (dry basis): crude protein, 3.44–10.06; ether extr., 0.88–2.18; crude fibre, 29.81–41.36; N-free extr., 41.26–51.66; and total ash, 8.21–20.25%: calcium, 0.36–0.48; phosphorus, 0.19–0.44; magnesium, 0.39–0.92; sodium, 0.25–0.34; potassium, 0.74–1.39; chlorine, 0.09–0.27; and sulphur, 0.06–0.12%; oxalic acid, 1.06–1.7%. The feed value of grass is higher at the pre-flowering stage. Feeding trials on adult sheep show that hay (protein, 4.4; digestible protein, 1.61; and total digestible nutrients, 55.8%; nutritive ratio, 33.7) gives positive balances for nitrogen, calcium and phosphorus. Dairy cows fed on the grass improved in live weight and gave increased milk yield (Barua *et al.*, *Indian J. vet. Sci.*, 1951, **21**, 17, 25; *Bull. imp. Inst., Lond.*, 1922, **20**, 300).

The grass is reported to be proof against fires. The odour of fresh grass is believed to repel insects; trials

carried out in India show that the grass has no value as an insect-repellent. The odour of grass is attributed to a brown volatile oil (yield, 0.001%) exuded by the glandular hairs on the stems. The oil is acidic with a cumin-like odour and contains fatty acids, esters and, probably, a phenolic substance (*Kew Bull.*, 1922, 305 ; *Indian Fmg*, 1946, **7**, 154 ; Dalziel, 531).

MELIOSMA Blume (*Sabiaceae*)

Fl. Br. Ind., II, 3.

A genus of trees or shrubs distributed in South-East Asia and tropical America. About nine species are found in India.

M. dilleniaefolia Walp. (PUNJAB HILLS -*Kanna, karkon* ; KUMAON *Gulpha* ; NEPAL *Lekh gogun, rani gogun*) is a small tree with elliptic, obovate or oblanceolate leaves and small white flowers found almost throughout the Himalayas at altitudes of 1,200–3,300 m. The leaves of the tree are used as fodder (Laurie, *Indian For. Leafl.*, No. 82, 1945, 9).

M. microcarpa Craib syn. *M. arnottiana* Walp. ; Hook. f. (Fl. Br. Ind.) (TAM. -*Kusavi, thagari, hulimakai* ; KAN.—*Massivala* ; MAL.—*Kalavi*) is a handsome tree, up to 12 m. high, with imparipinnate leaves and minute creamy white, fragrant flowers found in Khasi hills, Manipur and Deccan Peninsula from S. Kanara southwards up to an altitude of 2,100 m. ; it is also cultivated in gardens. The wood is dark reddish brown, soft, almost spongy, coarse and light (wt., 25 lb./cu.ft.). It is used for agricultural implements, poles and floats (Krishnamurthi, 218 ; Gamble, 206 ; Cameron, 78 ; Lewis, 122).

M. pinnata Roxb. (BENG.—*Bativa* ; ASSAM—*Hengunia, banpasola*) is a medium-sized tree with imparipinnate leaves, white flowers and globose drupes found in eastern Himalayas and Assam up to an altitude of 1,500 m. The fruit is edible ; young leaves are cooked and eaten with fish [Fischer, *Rec. bot. Surv. India*, 1938, **12**(2), 88 ; Fl. Assam, I, 329].

M. simplicifolia Walp. (BENG.—*Dibru, dantrangi* ; NEPAL *Patpate, chiwari* ; ASSAM—*Thowthowa, larubandha* ; TAM. —*Cembavu, kallavi*) is a medium-sized tree with obovate to oblanceolate leaves and yellowish white flowers found in north-east India and Deccan Peninsula, up to an altitude of 1,350 m. The wood is reddish brown, even-grained, moderately hard and light (wt., 25 lb./cu.ft.) ; it is liable to warp and split. The wood is suitable for light temporary structures ; it may be used also for pencils. It is a good fuelwood (calorific value : *sapwood*—4,987 cal., 8,978 B.t.u. ; *heartwood*—4,855 cal., 8,740 B.t.u.) (Lewis, 122 ; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 20 ; Rehman & Ishaq, *Indian For. Leafl.*, No. 66, 1945).

M. thomsonii King ex Brandis (NEPAL—*Sindure, dabdabe*) is a large tree found in eastern Himalayas. It has been recommended for cultivation in tea estates in Darjeeling for timber and fuel purposes (Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 142).

M. wallichii Planch. (NEPAL -*Lekh dabdabe* ; LEPCHA -*Hingman-kung* ; KHASI —*Dieng-sngit*) is a tree up to 18 m. in height and 1.5 m. in girth, with imparipinnate leaves and oblong to ovate, subcoriaceous leaflets found in the Himalayas from Kumaon eastwards and in Assam hills at altitudes of 750-2,400 m. The wood is brownish, soft, spongy and light (wt., 18 lb./cu.ft.). It is occasionally used for boxes. The tree provides fodder of medium quality (Gamble, 206 ; Fl. Assam, I, 328 ; Laurie, loc. cit.).

MELISSA Linn. (*Labiatae*)

A small genus of perennial herbs distributed in the Mediterranean region and Asia. Two species occur in India.

M. parviflora Benth.

Fl. Br. Ind., IV, 651 ; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 100 ; Kirt. & Basu, Pl. 761B.

HINDI *Bililotan*.

An erect, pubescent or glabrate herb, 60–100 cm. high, found in the temperate Himalayas from Garhwal to Sikkim, Darjeeling and Khasi, Aka and Mishmi hills, at altitudes of 1,200–3,000 m. Leaves ovate or ovate-lanceolate, crenate ; flowers white or pale pink, rarely yellow, in few or many flowered axillary whorls ; nutlets narrowly obovoid, dark, rugulose.

The plant is considered a good substitute for *M. officinalis* Linn. (Lemon Balm) and is said to possess stomachic, antitubercular and antipyretic properties ; it is used to strengthen the gum and to remove bad taste from the mouth. The fruit is considered a brain tonic and useful in hypochondriac conditions (Kirt. & Basu, III, 1993 ; Nadkarni, I, 786 ; Chopra, 1958, 601).

Melocalamus — *see* **Dinochloa**

MELOCANNA Trin. (*Gramineae*)

A genus of bamboos distributed chiefly in the Indo-Malayan region. One species is found in India.

M. bambusoides Trin.

D.E.P., V, 225; C.P., 103; Fl. Br. Ind., VII, 417; Chatterjee, *J. Bombay nat. Hist. Soc.*, 1960, **57**, 451, Fig. 1–4.

Beng.—*Muli, metunga, bish.*

Assam—*Tarai, wati.*

An arborescent bamboo found in the Garo, Khasi and Lushai hills in Assam. Culms erect, up to 21 m. in length and 9.5 cm. in diam., arising singly from a ramifying rhizome; leaves lanceolate or oblong-lanceolate; flowers in large compound panicles of drooping branches with secund clustered spikelets; fruit (caryopsis) pyriform, fleshy, 7.5–12.5 cm. long, often viviparous, edible.

M. bambusoides is typically gregarious and spreads by its long vigorous rhizomes. The fruits germinate soon after falling to the ground at the commencement of the rainy season. Seedlings do not thrive under shade but spring up readily in gaps. They grow vigorously and culms attain their maximum height in c. 5 years. Artificial regeneration may be done by sowing fruits directly at site or by transplanting nursery-raised seedlings; propagation by offsets and rhizome sections is also easy. A spacing of 3.6 m. × 3.6 m. has been recommended. Young shoots are liable to attack by the beetle, *Cyrtotrachelus longipes* Fabr. [Troup, III, 1011; Badhwar & Kadambi, *Indian For.*, 1956, **82**, 524; Hadfield, *Two & A Bud*, 1958, **5**(2), 9; Gamble, 756; Stebbing, 440].

The culms are straight and thin walled, but strong and durable, with slight knots. The average weight of a dry culm, 6.6 m. long × 9.5 cm. diam. at mid-girth is 1.55 lb. Preservative treatment with 14.85% zinc chloride solution for 5 hr. by the modified Bucherie process has given satisfactory results (Pearson, *Indian For. Rec.*, 1912, **4**, 184; Narayanamurti *et al.*, *Indian For. Bull.*, *N.S.*, No. 137, 1947).

M. bambusoides is used for purposes for which bamboos are generally employed. It is especially prized for house building, scaffolding and boat making. It contains (oven-dry basis): cellulose, 62.3; lignin, 24.1; pentosans, 15.1; hot water solubles, 6.5; ash, 1.9; and silica, 1.5%. It is suitable for the production of paper pulp after removing the sheaths (yield of bleached pulp, 42%). Activated charcoal of high adsorption power has been prepared from the bamboo. The culms contain abundant amounts of a siliceous secretion, known commonly as *tabasheer* and used in medicine (Wlth India—Raw Materials, I, 145; Mukherjee & Bhattacharyya, *J. sci. industr. Res.*, 1947, **6B**, 8).

F.R.I., Dehra Dun

FIG. 116. MELOCANNA BAMBUSOIDES

MELOCHIA Linn. (*Sterculiaceae*)

A genus of herbs, undershrubs and shrubs, rarely trees, distributed throughout the tropics. Two species occur in India; a few exotics are found as weeds.

M. corchorifolia Linn.

D.E.P., V, 225; Fl. Br. Ind., I, 374.

Hindi—*Bilpat*; Beng.—*Tikiokra*; Tel.—*Ganuga pindikura*; Tam.—*Pinnak-kuppundu*; Mal.—*Ceruvuram*; Oriya—*Chyeron, dasokerotan.*

Mundari—*Dela ara, asa ara*; Santal—*Thuiak.*

An erect, branched herb or undershrub found in waste places, road sides, bunds of rice fields and fallow lands almost throughout the hotter parts of India, and ascending to 1,200 m. in the Himalayas. Leaves ovate-oblong, serrate, sometimes obscurely lobed; flowers small, white or pink, in terminal or axillary

FIG. 117. MELOCHIA CORCHORIFOLIA—FLOWERING BRANCH

heads; capsules depressed globose, of the size of a small pea.

The stem bark yields a strong, silvery white fibre. The fibre (ultimate cell length, 1.1 mm.; diam., 11.2 μ; length/diam. ratio, 98) shows: elongation at break, 6.0% and intrinsic strength, 0.967 ± 0.036 g./denier. Analysis of fibre gave the following values: cellulose, 80.34; lignin, 17.87; fat & wax, 1.27; nitrogen, 0.22; and ash, 0.497%. The fibre is used for tying bundles of rice plants and for making fishing lines; stems are employed for horizontal ties in hut roofs (Burkill, II, 1448; Betrabet, *J. sci. industr. Res.*, 1956, **15B,** 671; Dalziel, 108).

Leaves are eaten as vegetable and sometimes used in soups. They are applied as poultice for sores and swellings of the abdomen. A decoction of the leaves and roots is used in dysentery (Dalziel, 108; Burkill, II, 1448).

M. umbellata Stapf syn. *M. velutina* Bedd.

D.E.P., V, 226; II, 567; Fl. Br. Ind., I, 374.

BOMBAY—*Methuri*; ANDAMAN IS.—*Al-abada*.

A shrub or a small tree found in Deccan, Konkan, Coorg, Kerala and Andaman Islands. Leaves broadly ovate or sub-orbicular; flowers small, pink, in umbellate corymbs; capsules oblong, deeply 5-lobed.

FIG. 118. MELOCHIA UMBELLATA—FLOWERING BRANCH

The plant is often cultivated in gardens. It grows fast and is useful as a nurse plant in reafforestation and as shade tree (Fl. Madras, 110; Burkill, II, 1448).

The stem bark yields a fibre used for strings and ropes. In Andaman Islands, it is used for making turtle nets. The characteristics of the ultimate fibre are: length, 2.045 mm.; diam., 0.016 mm.; and lumen size, 7 μ (Brown, I, 397, 322).

The wood is whitish, soft, very light, even-grained and glossy. It is used for making tea boxes, floats and toys, and also as firewood (Burkill, II, 1449; Cameron, 37).

MELODINUS Forst. (*Apocynaceae*)

A small genus of erect or climbing shrubs found in South-East Asia and Australia. Two species occur in India.

M. monogynus Roxb.

D.E.P., V, 226, 330; Fl. Br. Ind., III, 629; Bor & Raizada, Fig. 127.

KHASI—*Soh-brab.*

A large climber with milky juice found in Sikkim Himalayas, North Bihar, North Bengal, Cooch Behar, Assam and Khasi and Jaintia hills up to 1,200 m. Leaves elliptic-oblong or oblong-lanceolate; flowers white, fragrant, in terminal panicled cymes; fruit a globose berry, of the size and colour of an orange, with numerous flattened seeds.

M. monogynus is occasionally cultivated in gardens for its bright, dark green leaves and white, fragrant flowers which bloom during spring: it is suitable for growing over arches and pergolas. It is propagated by seeds, cuttings or layers during rains (Bor & Raizada, 215).

The fruit possesses a sweet and agreeable taste and is edible. The bark contains a long and tough fibre which can be used as a substitute for hemp. The leaves, wood and root contain a narcotic poison. The plant is used locally as an antimalarial drug (Chopra *et al.*, 654; Chatterji *et al.*, *J. sci. industr. Res.*, 1954, **13B,** 546).

The roots, particularly the root bark, are bitter. A *β*-glucoside, provisionally named melodin ($C_{20}H_{36}O_8.H_2O$, m.p. 128°; yield, 0.1%), and two closely related triterpenes, lupan- 3:20-diol ($C_{30}H_{52}O_2$, m.p. 232°; yield, 0.7%) and lupeol ($C_{30}H_{50}O$; yield, 1.7%), have been isolated from the dried root bark. On hydrolysis, melodin yields glucose and melodinidin ($C_{19}H_{26}O_3$, m.p. 148°). Lupan- 3:20-diol is converted to lupeol on sublimation in high vacuum (160–66°/10^{-4} mm.) (Chatterji *et al.*, loc. cit.; Chatterjee *et al.*, *J. sci. industr. Res.*, 1959, **18B,** 262).

Melodorum — *see* **Fissistigma**

Melon — *see* **Cucumis**

Melon, Water — *see* **Citrullus**

MELOTHRIA Linn. (*Cucurbitaceae*)

A large genus of annual or perennial climbing or prostrate herbs distributed in the tropics of the world. About 12 species occur in India.

M. heterophylla (Lour.) Cogn. syn. *Zehneria umbellata* Thw.

D.E.P., VI (4), 355; Fl. Br. Ind., II, 625 (in part); Chakravarty, *Rec. bot. Surv. India*, 1959, **17**(1), 159; Kirt. & Basu, Pl. 466B.

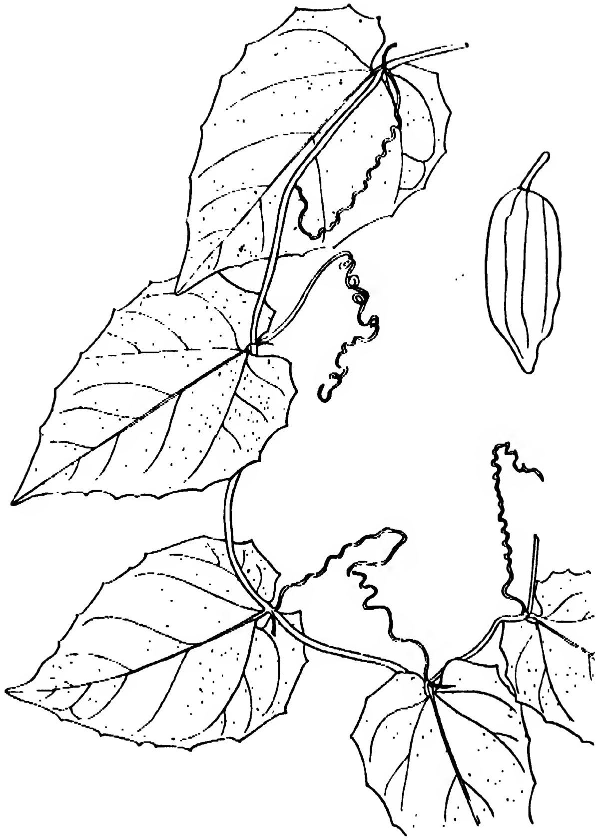


FIG. 119. MELOTHRIA HETEROPHYLLA

HINDI—*Tarali;* BENG.—*Kudari;* TEL.—*Thivyadonda;* TAM.—*Pulivanji;* MAL.—*Njerinjanpuli;* ORIYA—*Karakia, malka, makirla.*

BOMBAY—*Gometta, gometi;* PUNJAB—*Bankakra;* MUNDARI—*Birkunduru;* KHASI—*Soh-khia-phlang;* LUSHAI—*Zongawm pawng.*

A scandent herb with tuberous roots found throughout India ascending up to 2,100 m. in the hills. Leaves polymorphous, ovate, sub-orbicular, oblong or narrowly lanceolate, undivided or variously lobed, remotely denticulate; flowers small, yellow: male flowers various, sub-umbellate, umbellate, racemes or densely or laxly fascicled, female flowers solitary; fruits oblong, brown, with many subspherical, smooth seeds.

The roots, leaves and fruits are eaten. The root is considered stimulant, invigorating and purgative: it is used for gonorrhoea and dysuria. In Konkan, the juice of the root, mixed with cumin and sugar, is given in cold milk as a remedy for spermatorrhoea. Juice of leaves is applied to the parts inflamed by the application of the markingnut juice (from *Seme-*

carpus anacardium Linn.). In Indo-China, the seeds are used as a purgative (Haines, III, 390; Nadkarni, I, 1308; Burkill, II, 1450; Kirt. & Basu, II, 1163).

M. maderaspatana (Linn.) Cogn. syn. *Mukia scabrella* Arn.

D.E.P., V, 287; Fl. Br. Ind., II, 623; Chakravarty, *Rec. bot. Surv. India*, 1959, **17**(1), 141; Kirt. & Basu, Pl. 465.

HINDI—*Agumaki, bilari*; BENG.—*Bilari*; MAR.—*Ghugri*; TEL.—*Noogudosa, kooturubudama*; TAM.—*Musumusukkai*; MAL.—*Mukkalpeeram*.

BOMBAY—*Chirati*; PUNJAB—*Gwala kakri*.

A prostrate or climbing annual herb found throughout India ascending up to 1,800 m. in the hills. Leaves ovate or sub-deltoid, entire or 3–5 lobed, minutely denticulate; flowers small, yellow: male flowers fascicled, female flowers solitary or sub-fasciculate; fruits globose, brownish yellow; seeds ovoid-oblong, grey.

The fruits are eaten by parrots and other birds. The cattle are said to like the plant but the fruits are said to destroy their eyes. The tender shoots and bitter leaves are used as a gentle aperient, and prescribed in vertigo and biliousness. The root of the plant, when masticated, relieves toothache; a decoction of root is given in flatulence. On account of its expectorant properties, the plant is sometimes used in compound preparations for cough, but trials indicate that its action is slow and unsatisfactory. A decoction of seeds is considered sudorific (Fl. Delhi, 178–79; Kirt. & Basu, II, 1161; Koman, 1920, 3).

M. indica Lour. is a scandent or spreading herb found in Tehri Garhwal, Sikkim, Assam and Naga hills up to 1,800 m. In Moluccas, the juice of the leaves is applied in sores of thrush, and is used in the treatment of eye diseases. The fruit possesses purgative properties (Burkill, II, 1450; Quisumbing, 943).

M. perpusilla (Blume) Cogn. syn. *Zehneria hookeriana* Arn. (BOMBAY—*Varali*) is a climbing herb found in the upper Gangetic plain, from Nepal to Assam ascending up to 2,100 m. in the eastern Himalayas and in peninsular India. The root of the plant is used with milk in fever and diarrhoea (Kirt. & Basu, II, 1162).

MEMECYLON Linn. (*Melastomataceae*)

A genus of shrubs and trees distributed chiefly in the tropics of the Old World. Over 30 species occur in India.

M. umbellatum Burm. f. syn. *M. edule* Roxb. IRON WOOD TREE

D.E.P., V, 226; Fl. Br. Ind., II, 563; Kirt. & Basu, Pl. 429.

MAR.—*Anjani, kurpa, limba*; TEL.—*Alli, kikkalli, uddalalli*; TAM.—*Alli, anjani, kaya*; KAN.—*Archeti, harchari, lakhonde*; MAL.—*Kashavu, kanalei, kannavu*; ORIYA—*Nirassa, bonohorono*.

ASSAM—*Lali-dimabophang, theihadum*.

A large ornamental shrub or a small tree found mostly in the coastal regions of Deccan Peninsula, eastern parts of India and the Andaman Islands. Bark greyish with vertical furrows; leaves elliptic or ovate, shiny; flowers in umbellate cymes, bright blue; berries globose, purplish or black. The plant is handsome in bloom and is grown for ornament. It may be grown from seed or by layers; cut stumps coppice well. It flowers during March–April and fruits appear in the beginning of rains.

This species embraces a number of varieties, some of which have been raised to specific rank by different authors. They are, however, not discriminated in their economic uses (Fl. Madras, 504).

The fruits are pulpy, astringent and edible. The leaves possess cooling and astringent properties and are given in leucorrhoea and gonorrhoea; a lotion prepared from them is used in eye troubles. The leaves and the bark are applied to bruises. The leaves yield a yellow dye which gives beautiful light shades; in combination with myrobalans and sappanwood it produces a bright red tinge much used for dyeing mats. The dye content is, however, low. The leaves contain a yellow glycosidal substance, tartaric and malic acids (1.38%), a resin (6%) and calcium oxalate (1.44%). Dried leaves form a fine mulch for garden soil. Analysis of dry leaves gave the following values: N, 1.15; ash, 7.71; and CaO, 2.16% (Kirt. & Basu, II, 1065–66; Burkill, II, 1452; Lewis, 200; Wehmer, II, 864; Puri, *J. Indian bot. Soc.*, 1954, **33**, 17).

The sapwood is greyish brown, turning dark brown on exposure; heartwood small, darker than sapwood. The wood is hard, heavy (wt., 62 lb./cu.ft.), fine-textured, close-grained and durable, and can be finished to a smooth surface. It is used for house posts and rafters, light axe handles, pestles, combs, walking sticks and decorative work; it may be employed as a substitute for boxwood. The wood yields charcoal of good quality [Chowdhury & Ghosh, *Indian For. Rec., N.S., Util.*, 1947, **4**(3), 15; Burkill, II, 1452; Howard, 363; Lewis, 200].

M. angustifolium Wight (TAM.—*Vellaikkaya*; KAN.—*Belavakana*; MAL.—*Attakanalai*) is a shrub or a small tree with purplish blue flowers and black purple berries found in Courtallum and Shevaroy hill forests (South India) along river banks. The bark of the plant is used as a tonic and refrigerant (Kirt. & Basu, II, 1067).

M. caeruleum Jack is a handsome shrub or a small tree, with bright blue flowers and black fruits, occurring sparsely in middle Andamans. It is reported to be cultivated in gardens. The fruit and leaves are eaten. The wood is hard and heavy, useful for house construction. It also affords good fuel (Burkill, II, 1451).

M. ceraciforme Kurz (ASSAM—*Kakoi-chera*) is a small tree with elliptic leaves and blue black berries, found in Sibsagar dist. (Assam). The wood is reddish brown and tough and used for axe handles (Fl. Assam, II, 306).

M. gracile Bedd. (MAL.—*Elimarom*) is a pretty shrub or a small tree with pale blue flowers and globose berries found in the evergreen forests of Kerala and Tirunelveli. The wood is hard and tough, and good for walking sticks (Bourdillon, 173).

M. malabaricum Cogn. (including *M. depressum* Benth.) syn. *M. amplexicaule* var. *malabarica* C. B. Clarke (Fl. Br. Ind.)* (MAR. *Limba*; TAM.—*Malamthetti, kanjavu*; KAN. *Locundi, limbtoli*; MAL.—*Kaikkathetti, kashavu*) is a shrub or a small tree with clusters of blue flowers found on the lower slopes of western ghats in Kerala and in the moist sholas of Nilgiri and Palni hills up to an altitude of 2,000 m. The wood is greyish brown, hard, heavy (wt., 65 lb./cu.ft.) and close-grained. It has been suggested as a possible substitute for boxwood; it is good as fuel. The root has ecbolic properties. A decoction of the flowers and twigs is used for skin diseases (Rama Rao, 178; Bourdillon, 174; Fl. Madras, 505; Kirt. & Basu, II, 1066).

MENTHA Linn. (*Labiatae*)

A small genus of aromatic perennial herbs distributed mainly in the temperate regions of the Old World. Several species have been introduced into various countries and are cultivated for their aromatic leaves and flowers. About 6 species are recorded in India.

Mentha species are extremely variable and specific limits are hard to define, with consequent unstable nomenclature. All cultivated types are said to belong to 3 or 4 species, which have hybridized among themselves, resulting in a number of inter-grading hybrids, often designated as separate species. They appear to differ not only in morphological features, but also in flavour and essential oil content. Many of them have escaped from cultivation and grow naturally in moist situations; some are sterile or only half-fertile and have been perpetuated by vegetative propagation (Chittenden, III, 1286; Bailey, 1947, II, 2034; Guenther, III, 586, 640; De Wolf, *Baileya*, 1954, **2**, 3; Morton, *Watsonia*, 1953-56, **3**, 244).

M. aquatica Linn. WATER MINT, MARSH MINT

Fl. Br. Ind., IV, 647; Bailey, 1949, 863; De Wolf, *Baileya*, 1954, **2**, 3, Fig. 6A.

A variable perennial herb with weak, glabrous to distinctly pubescent stems, probably cultivated in Indian gardens. Leaves ovate, lanceolate to cordate, 1.25-5.0 cm. long, crisped, laciniate to serrate, obtuse to acute, shortly petioled; flowers in verticillasters forming a short, broad, capitate raceme.

This species is a native of Europe, and has become naturalized in several other countries. It is found in swamps, marshes and on borders of rivers and ponds throughout Europe, western Asia, N. and S. Africa. It comprises a large range of polymorphic types, showing variation in most of the characters. It is considered to be one of the putative ancestors of several cultivated mints. By crossing with *M. spicata*, it is said to have given rise to clones of *M. piperita* and *M. citrata*; and with *M. arvensis*, to *M. verticillata* and a few others. The typical form is rather pubescent, but there are forms with glabrous leaves, known as Lemon or Bergamot Mints and classified as *M. citrata* Linn.; similarly crisped leaved forms often grown as *M. crispa* Linn. or *M. aquatica* var. *crispa* Benth., are considered to be chance mutants of this species (Clapham *et al.*, 936; Graham, *Watsonia*, 1953-56, **3**, 109; Guenther, III, 685; De Wolf, loc. cit.; Hocking, 138).

Marsh mint has a characteristic odour and aromatic taste and is used as emetic, stimulant and astringent. The crisped leaved mint is a digestive; it is used in gall and stomach disorders; it is used also for flavouring foods and liqueurs. The flowers produce a dull yellow stain on aluminium-mordanted cotton (Muenscher & Rice, 105; Wren, 369; Steinmetz, II, 298; Perkin & Everest, 636).

* Gamble assigns *M. amplexicaule* var. *malabarica* C. B. Clarke (Fl. Br. Ind.) partly to *M. malabaricum* Cogn. and partly to *M. depressum* Benth.; the former is confined to higher elevations and the latter to elevations up to 365 m. The two species are not discriminated for economic uses (Fl. Madras, 505).

The herb yields up to 0.8% of an essential oil with a faint mint-like odour. An oil of Sicilian origin has the following characteristics: sp. gr.$^{15°}$, 0.9671; $[\alpha]_D^{20°}$, +39.9°; $n^{20°}$, 1.4883; ester val., 63.40; ester (as menthyl acetate), 22.41%; free alcohol (as menthol), 28.53%; and ketone (as menthone), 0.77%. It contains carvone ($C_{10}H_{14}O$, b.p. 230°), and probably also menthol, menthyl acetate, menthyl valerate, pulegone and menthone. Recent studies have shown that menthofuran ($C_{10}H_{14}O$, b.p. 196°) is the major component (40%); piperitone, menthone and pulegone are present. The oil has not attained commercial importance (Guenther, III, 684; Reitsema, *J. Amer. pharm. Ass., sci. Edn*, 1958, **47**, 265, 267).

M. arvensis Linn. FIELD MINT, CORN MINT

D.E.P., V, 228; Fl. Br. Ind., IV, 648; De Wolf, *Baileya*, 1954, **2**, 3, Fig. 6B.

HINDI, BENG., MAR., GUJ. & TEL. *Podina, pudina*; KAN.—*Chetni maragu*.

An erect, hairy or glabrous herb, 10–60 cm. high, found throughout temperate North Asia up to the Himalayas and in Europe. Leaves 2.5–5 cm. long, shortly petioled or sessile, oblong-ovate or lanceolate, obtusely or acutely serrate, cuneate at the base, sparsely hairy or almost glabrous; flowers lilac, in axillary, capitate whorls, borne on axils of leaves on upper stem.

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FIG. 120. MENTHA ARVENSIS—FLOWERING BRANCH

This species grows wild in Kashmir at 1,500–3,000 m. and is common near Gulmarg; it has also been recorded in a few other places in India, but is nowhere cultivated on a commercial scale. It is very variable. It crosses easily with *M. aquatica* giving an extremely variable progeny; it also hybridizes with *M. spicata*. Some of the reported hybrid species and varieties are: *M. verticillata* Linn., *M. gentilis* Linn., *M. gracilis* Sole, *M. cardiaca* Baker, and *M. arvensis* var. *piperascens* [Handa *et al.*, *J. sci. industr. Res.*, 1957, **16A**(5), suppl., 13; Muenscher & Rice, 103; Guenther, III, 640; Graham, *Watsonia*, 1948–50, **1**, 276; Clapham *et al.*, 934–35; De Wolf, loc. cit.].

Field mint is used locally as a stimulant and carminative. An infusion of leaves affords a remedy for rheumatism and indigestion. The volatile oil obtained from the plant growing in Kashmir (yield, 0.45%; sp. gr.$^{15°}$, 0.9161; $n^{20°}$, 1.474) does not conform to official standards; for instance, menthol does not separate out on chilling the oil (Chopra *et al.*, *Indian J. agric. Sci.*, 1946, **16**, 302; Kapoor *et al.*, *J. sci. industr. Res.*, 1955, **14A**, 374; Handa *et al.*, loc. cit).

M. arvensis Linn. subsp. **haplocalyx** Briq. var. **piperascens** Holmes JAPANESE MINT

Bailey, 1947, II, 2035.

A downy perennial herb with running rootstocks and rigid branching stem, 60–90 cm. high, introduced from Japan and cultivated in Jammu and Kashmir at an altitude of 270–1,500 m. Leaves lanceolate or oblong, sharply toothed, 3.7–10 cm. long, shortly petioled or sessile, with minute hairs; flowers purplish, in loose verticillasters, in rather distant nodes.

This species is more robust than *M. arvensis* and is a high numbered polyploid; it does not breed true from seed. It is a clonal form, evidently from a hybrid between *M. arvensis* and *M. aquatica*, perpetuated by vegetative methods for its high menthol content. It is extensively cultivated in Japan, where it yields the bulk supply of menthol and the Japanese Peppermint Oil (Guenther, III, 640, 664; De Wolf, loc. cit.).

Japanese mint thrives well in Jammu (270 m.) and Katra (900 m.); in Srinagar (1,500 m.), it becomes stunted and does not flower until late in the season. Large scale cultivation has been undertaken in certain farms in Jammu. Trials elsewhere in India have indicated possibilities of its successful cultiva-

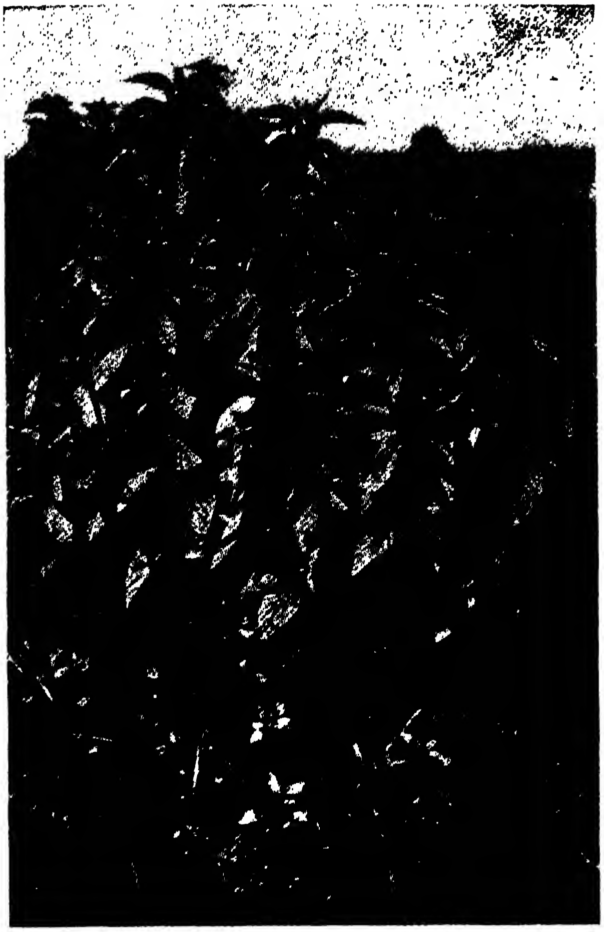

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FIG. 121. MENTHA ARVENSIS *VAR.* PIPERASCENS—HABIT

tion [Kapoor *et al.*, loc. cit.; Handa *et al.*, loc. cit.; Gupta & Gupta, *Indian Perfum.*, 1959, **3**, 5; Kulkarni, *Indian Hort.*, 1958–59, 3(3), 32; Pillai & Soman, *Bull. Res. Inst., Univ. Kerala*, 1959, **6A**(1), 26; Subramaniam, *Madras agric. J.*, 1960, **47**, 153].

The plant is propagated by rooted suckers taken from old vigorous plants. It thrives well in sandy or loamy soils rich in humus. A well drained soil, with slight rain in spring and bright sunshine in summer gives plants with high menthol content. Liberal irrigation is necessary. A basal dressing of farmyard manure or compost at 12 tons per acre, followed by supplementary dressings of inorganic fertilizers (ammonium sulphate, 200 lb.; superphosphate, 200 lb.; and potassium sulphate, 200 lb.) has given good results.

Rooted suckers planted in March and liberally irrigated during summer, flower in July and yield a crop 200–300 md./acre, containing 45% stems and 50% leaves. The same crop gives a second flush in October, the yield amounting to 100 md./acre; good crops are obtained in second and third years also, by intercultivation and irrigation at regular intervals. The yield of oil diminishes after the third year and it is economical to uproot the crop and replant after suitable rotation. For the latter purpose a leguminous crop, like senna (*Cassia angustifolia*) or beans, is recommended.

The plants are harvested at full bloom. According to climatic conditions, one or two flushes may be harvested. The crop is cut in the morning on a bright sunny day after the dew has cleared. Cut plants are tied in small bundles and dried in open air or in a shed to about $\frac{1}{3}$ their fresh weight. Sun-drying is not advisable, since the oil yield is affected due to evaporation and resinification (Kapoor *et al.*, loc. cit.; Handa *et al.*, loc. cit.).

The herb yields, on steam-distillation, a volatile oil, known in the trade as Japanese Mint Oil or Japanese Peppermint Oil; leaves and flowering tops give the highest yield. The oil is usually distilled from partially dried herb, and yields varying from 1.28 to 1.6% have been reported from Japan. Leaves collected from experimental plots in Jammu have given a yield of

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FIG. 122. MENTHA ARVENSIS *VAR.* PIPERASCENS—FLOWERING BRANCH

2% (on dry wt. basis), while the yield from fresh leaves from U.P. is reported to be 0.45% (Guenther, III, 646–50; Kapoor *et al.*, loc. cit.; Gupta & Gupta, loc. cit.).

Japanese mint oil is used as a substitute for true peppermint oil (from *M. piperita*) which it resembles in physico-chemical properties. It possesses a somewhat bitter odour and flavour, and is considered inferior to *M. piperita* oil in aroma and quality. On cooling, menthol separates out; the residual dementholized oil contains up to 55% menthol. The characteristics of the natural and dementholized oils from different sources are given in Table 1. Japanese mint oil is not official in British and United States Pharmacopoeias. The Indian Pharmacopoeia recognizes oils from various mints containing more than 50% menthol (Guenther, III, 618, 650–52; Chopra, 1958, 197; I.P., 433).

In addition to menthol, which is the main constituent, the oil contains menthyl acetate, menthone and minor amounts of piperitone, α-pinene, furfural, *l*-limonene, camphene, caryophyllene, *d*-3-octanol, a *dl*-sesquiterpene alcohol, β,γ-hexenyl phenyl acetate, α,β-hexenic acid and other free and esterified fatty acids. The oil distilled from plants grown in Jammu contains 70–80% menthol; dementholized oil has the following composition: menthol, 44.8; menthyl acetate, 24.4; menthone, 24.6; and hydrocarbons, 6.2%; *l*-α-pinene, *l*-limonene, caryophyllene, cadinene and an unidentified sesquiterpene have been identified (Guenther, III, 655–57; Chaudhari & Handa, *Indian J. Pharm.*, 1956, **18**, 421).

Japanese mint oil finds uses similar to that of peppermint oil (q.v.); the latter is preferred for flavouring purposes. It is used for the production of natural menthol. Dementholized oil is employed for flavouring mouth washes, tooth pastes and pharmaceutical preparations (Guenther, III, 650–52, 664; Poucher, I, 329).

The world's demand for Japanese mint oil and natural menthol is met mainly by Japan and to a lesser extent by China and Brazil. Cultivation of Japanese mint in Jammu and parts of U.P. has given promising results with respect to both yield of oil per acre and the menthol content of the oil. The Forest Department in U.P. proposes to take up the cultivation of plant on a commercial scale (Guenther, III, 664; Kapoor *et al.*, loc. cit.; Gupta, *Indian Oil & Soap J.*, 1959–60, **25**, 297).

Japanese mint oil is not distinguished from true peppermint oil in Indian trade. Table 2 gives the imports of peppermint oil (including Japanese mint oil) and menthol during the years 1957–60; data for Japanese mint oil are not separately available. The entire quantity imported from Japan and China is probably Japanese mint oil, though the plant grown in China is considered to be a different variety of *M. arvensis*, namely var. *glabrata* Holmes which is

TABLE 1—CHARACTERISTICS OF JAPANESE MINT OILS

	Natural oil			Dementholized oil	
	Jammu[1]	Kanpur[2]	Japan[3]	Jammu[1]	Japan[3]
Sp. gr.	0.9165 (at 20°/20°)	0.8966 (at 30°)	0.895–0.902 (at 24–25°)	0.8980 (at 20°/20°)	0.895–0.907 (at 15°)
$[\alpha]_D$	−41.75° (at 20°)	−41.8°	−29° to −42° (at 20°)	−37.2° (at 20°)	−20.3° to −35° (at 20°)
n	1.4568 (at 20°)	1.4528 (at 30°)	1.460–1.463 (at 20°)	1.4580 (at 20°)	1.459–1.463 (at 20°)
Acid val.	0.64	0.5	2.0	1.14	2.0
Menthol, %	75.8	72.6	69–91 (total)	44.8	48–55 (total)
Esters, as menthyl acetate, %	10.9	18.2	3–6	24.4	4–15
Menthone, %	10.9	8.8	..	24.6	21–34
Solubility in 70% alcohol	sol. in 6.7 vol.	sol. in 2 vol. and more	sol. in 2–3 vol. and more	sol. in 3 vol.	sol. in 2.5–4 vol. and more

[1] Chaudhari & Handa, *Indian J. Pharm.*, 1956, **18**, 421.
[2] Gupta & Gupta, *Indian Perfum.*, 1959, **3**, 5.
[3] Guenther, III, 654.

TABLE 2—IMPORTS OF PEPPERMINT OIL AND MENTHOL INTO INDIA
(Qty in lb.)

Country of origin	Peppermint oil				Menthol			
	1957	1958	1959	1960	1957	1958	1959	1960
U.K.	6,956	1,665	1,987	3,086	22,939	18,297	7,912	8,272
W. Germany	1,701	271	523	2,331	6,023	130	5,673	8,326
Netherlands	4,299	4,235	3,580	4,980	762	2,963	354	380
France	3,642	5,452	10,406	7,772	32,877	35,407	70,318	14,844
Hongkong	100	20	193	478	1,233	16,260	6,600	1,456
Japan	1,808	3,278	2,458	4,395	32,743	1,312	1,922	1,544
China	1,818	767	234	403	12,890	32,303	42,614	1,277
U.S.A.	3,179	4,727	2,940	16,614	30,546	509	1,909	3,602
Brazil	..	..	..	..	27,789	58,539	48,231	1,978
Others	468	1,188	5,019	5,723	422	2,385	5,258	4,936
Total Qty (lb.)	23,971	21,603	27,340	45,782	168,224	168,105	190,971	46,615
Total Val. (Rs.)	447,350	387,190	430,081	918,267	6,131,212	4,133,946	4,787,685	1,205,956

closely related to var. *piperascens* (Guenther, III, 640, 661).

M. longifolia (Linn.) Nathh. syn. *M. sylvestris* Linn. HORSEMINT

D.E.P., V, 230; Fl. Br. Ind., IV, 647; De Wolf, *Baileya*, 1954, **2**, 3, Fig. 3B.

HINDI—*Podina, jungli pudina.*

PUNJAB—*Baburi, belanne, koshk, pudnakushma*; BOMBAY—*Pudina, vartalau.*

An erect or diffuse herb, 30–100 cm. high, with a strong aromatic odour found in temperate Himalayas and western Tibet at 1,200–3,600 m. and in Kashmir, Garhwal, Kumaon and Punjab. Stems robust or slender, hoary-tomentose; leaves 3–8 cm. long × 1–3 cm. broad, shortly petioled or sessile, ovate lanceolate, acute, sharply toothed, pinnately veined, pubescent above, hoary-tomentose below; spikes terminal, 3–8 cm. long, slender, hoary; flowers lilac, in verticillasters, rather compact, rarely distant.

This species is very variable and includes *c.* 21 subspecies and 150 types. Some of them resemble *M. spicata*, while others approach *M. rotundifolia* and *M. tomentosa* D'Urv. In India, two varieties are distinguished, var. *incana* Willd. and var. *royleana* Benth., the former with slender, much interrupted spikes and the latter with usually stout, continuous spikes (De Wolf, loc. cit.).

Horsemint is considered carminative, antiseptic and stimulant. The leaves of var. *incana* are astringent and used for rheumatic pains. A decoction of the plant is used in fever and heat apoplexy. The plant is eaten in the form of chutney (Kirt. & Basu, III, 1982; Steinmetz, II, 299).

Steam-distillation of dried leaves and flowering tops of the plant from Kashmir gave 1.2% of a pale yellow

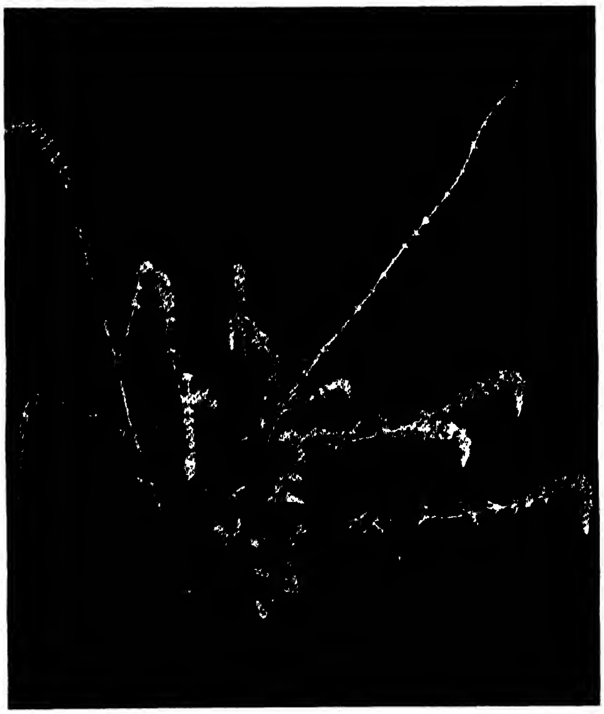

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FIG. 123. MENTHA LONGIFOLIA—FLOWERING BRANCH

oil (sp. gr.$^{15°}$, 0.985 ; $n^{20°}$, 1.471 ; ester val., 65.8) with a minty odour. Analysis of a sample of oil from U.S.A. showed that it contains piperitone oxide (45%), diosphenol, piperitenone, piperitenone oxide and diosphenolene. The oil can be used as a substitute for imported peppermint oil for flavouring confectionery (Handa *et al.*, loc. cit. ; Reitsema, *J. Amer. pharm. Ass., sci. Edn*, 1958, **47**, 265, 267).

M. piperita Linn. emend. Huds. PEPPERMINT

D.E.P., V. 229 ; Bailey, 1947, II, 2035 ; De Wolf, *Baileya*, 1954, **2**, 3, Fig. 4B.

HINDI *Paparaminta, gamathi phudina.*

PUNJAB—*Vilayati pudina.*

A perennial, glabrous, strongly scented herb, occurring spontaneously or cultivated in temperate regions of Europe, Asia, North America and Australia. It is grown in Indian gardens and also cultivated in Kashmir, Nilgiris, Mysore, Delhi and Dehra Dun. Stems erect, 30–90 cm. high, purplish or green ; leaves ovate or oblong-lanceolate, petioled, 2.5–10 cm. long, acute or obtuse at the base, coarsely serrate, smooth and dark green above, pale or sparingly hairy below ; flowers purplish, in thick terminal spikes.

M. piperita is considered to be a hybrid between *M. spicata* and *M. aquatica* ; according to some

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FIG. 124. MENTHA PIPERITA—FLOWERING BRANCH

M. spicata itself is a hybrid of *M. longifolia* and *M. rotundifolia* ; so *M. piperita* is a triple hybrid. Several clones of the taxon are cultivated ; among them Black Mitcham Mint (*M. piperita* var. *piperita* forma *piperita* syn. *M. piperita* var. *vulgaris* Sole forma *rubescens* A. Camus) and White Mitcham Mint (*M. piperita* var. *piperita* forma *pallescens* A. Camus syn. *M. piperita* var. *officinalis* Sole forma *pallescens* A. Camus) are important ; the former bears dark green leaves and gives a higher yield of oil than the latter, which yields an oil of superior quality but is less vigorous and more sensitive to climatic conditions, insects and diseases. Black Mint is favoured for commercial cultivation (Handa *et al.*, loc. cit. ; Graham, *Watsonia*, 1951–53, **2**, 30 ; De Wolf, loc. cit. ; Guenther, III, 586, 628 ; *Bull. Minist. Agric., Lond.*, No. 76, 1951, 36 ; Mansfeld, 374).

Peppermint thrives well in humid and temperate climates and is sensitive to drought. It grows well on light calcareous soils or deep rich loams in open sunny situations. It is propagated by cuttings of rootstocks planted in rows 30–90 cm. apart. Farmyard manure is applied as a basal dose before planting, and artificial fertilizers are applied during intercultivation. Planted in February or March, the plants flower in July of the second year, when the crop is harvested ; a second flush may be taken in September after the rains. Depending upon the nature of the soil, climatic conditions and cultural factors, an average yield of 3–4 tons of green mint per acre is obtained. Under favourable conditions, 10 12 lb. of oil per ton of partly dried mint is possible, an acre yielding roughly 30-40 lb. of the oil (Luthra, *Indian Fmg*, 1950, **11**, 10 ; Dhingra *et al.*, *Indian Soap J.*, 1951–52, **17**, 43 ; Green & Erickson, *Agric. Inform. Bull. U.S. Dep. Agric.*, No. 212, 1960 ; *Bull. Minist. Agric., Lond.*, No. 76, 1951, 36).

Dried leaves and flowering tops of the plant are official in U.S. Pharmacopoeia under the name Peppermint. The herb is considered aromatic, stimulant, stomachic and carminative, and used for allaying nausea, flatulence and vomiting. Bruised leaves are employed as an external application for relieving local pains and headache. A hot infusion is taken to allay stomach ache and colicky diarrhoea. The drug is frequently adulterated with spearmint, which is difficult to detect (Muenscher & Rice, 109 ; Wren, 268 ; Kirt. & Basu, III, 1980–81 ; U.S.D., 1955, 1015).

The herb is the source of true Peppermint Oil, extensively used for flavouring and in pharmacy ; it

TABLE 3—PHYSICO-CHEMICAL PROPERTIES OF PEPPERMINT OILS FROM DIFFERENT SOURCES

	Kashmir[1]	I.S. specifications[2]	France[3]	U.S.A.[3]	U.K.[3]
Sp. gr.	0.9046 (at 27°)	0.896–0.908 (at 30°/30°)	0.910–0.927 (at 15°/15°)	0.900–0.920 (at 15°/15°)	0.901–0.912 (at 15°/15°)
$[\alpha]_D$	–30.3°	–18° to –36°	–5° to –35°	–18° to –34°	–21° to –33°
n	1.4632 (at 27°)	1.4555–1.4655 (at 30°)	1.462–1.471 (at 20°)	1.4600–1.4640 (at 20°)	1.460–1.463 (at 20°)
Acid val.	1.4	..	..	..	up to 1.6
Menthol, %	55.8 (free)	$\nless$50 (free)	45–70 (total)	48–65 (total)	48.5–68.0 (total)
Ester, as menthyl acetate, %	20.0	4–20	4–21	3.7–11.0	3–21
Menthone, %	9.1	$\ngtr$25	17.4	9–25	9–12
Solubility in 70% alcohol	sol. in 2.7 vol.	sol. in 3.5 vol.	sol. usually in 1–1.5 vol. of 80% alc.	sol. in 2.5–5 vol.	sol. in 2–3.5 vol. and more

[1] Handa *et al.*, *J. sci. industr. Res.*, 1957, **16A**(5), suppl., 17. [2] IS: 528–1954; [3] Guenther, III, 632, 612, 629.

is official in many Pharmacopoeias. Commercial oils are derived from cured, partially dried plants while official oils are obtained from fresh material; the oil is rectified, if necessary. The yield of oil varies from 0.3 to 1% depending on the extent to which the material has been dried before distillation. Dried leaves and flowering tops from Kashmir gave 0.7–1.0% oil, while fresh mature leaves from Kanpur gave 0.32% oil (Guenther, III, 587–613; B.P.C., 1959, 542; Handa *et al.*, loc. cit.; Gupta & Gupta, *Indian Perfum.*, 1959, **3**, 5).

Peppermint oil is a colourless, pale yellow or greenish yellow liquid with a strong agreeable odour and a powerful aromatic taste, followed by a cooling sensation when air is drawn into the mouth. On ageing, the oil darkens in colour and becomes viscous. When chilled, menthol separates out. The physico-chemical properties of peppermint oils from Kashmir and other sources are given in Table 3 (B.P.C., 1959, 543).

The oil contains menthol (50–55%), menthyl acetate, menthone and small amounts of α-pinene, phellandrene, *l*-limonene, terpinene, cadinene, cineole, amyl alcohol, acetic acid, isovaleric acid, acetaldehyde, isovaleric aldehyde and a lactone. A sample of oil from Kashmir contained 15.1% hydrocarbons, including α-pinene, limonene and cadinene. Menthofuran and other trace compounds present in the higher boiling fractions account for the pleasant aroma of peppermint oil and distinguish it from Japanese mint oil. Dimethyl sulphide is present in the unrectified product (Guenther, III, 616–19, 613; Handa *et al.*, loc. cit.).

Peppermint oil is adulterated with dementholized Japanese mint oil, synthetic menthol, glycols, alcohol, benzyl alcohol, terpenes, terpineol, eucalyptus oil and pennyroyal oil; it is sometimes contaminated with spearmint oil (B.P.C., 1959, 543; Guenther, III, 614–15; U.S.D., 1955, 1016).

Peppermint oil is one of the most popular and widely used essential oils. It is employed for flavouring pharmaceuticals, dental preparations, mouth washes, cough drops, soaps, chewing gums, candies, confectionery and alcoholic liqueurs. It is valued in medicine both for internal and external uses; for internal use, it is preferred to menthol because of its more pleasant taste. It is widely employed in flatulence, nausea and gastralgia. It may be administered with sugar or in the form of tablets and lozenges. The oil has mild antiseptic and local anaesthetic properties. It is used as an external application in rheumatism, neuralgia, congestive headache and toothache (Guenther, III, 638; Hill, 463; U.S.D., 1955, 1016; B.P.C., 1959, 543; Nadkarni, I, 789).

India does not produce peppermint oil on a commercial scale, though the oil obtained from plants raised in Kashmir is up to official standards. Data relating to the import of peppermint oil (including Japanese mint oil) into India are given in Table 2. The principal exporting countries are France, Netherlands, U.K. and U.S.A. (Handa *et al.*, loc. cit.).

The green plant, left after the extraction of oil, may be dried into hay or silaged for use as cattle feed. The hay contains: protein, 12.7; digestible protein, 8.5; and total digestible nutrients, 49.4%; and nutritive ratio, 4.8. It may be employed as a

substitute for lucerne hay for feeding dairy cows (Morrison, 398, 1010).

M. pulegium Linn. ENGLISH OR EUROPEAN PENNYROYAL, PUDDING GRASS

Bailey, 1949, 863; De Wolf, *Baileya*, 1954, **2**, 3, Fig. 2A.

A much-branched, prostrate or creeping perennial with pubescent stems, 10–45 cm. long, found in most parts of Europe and circum-Mediterranean region; it has been introduced into various countries including India. Leaves shortly petioled, 1.25 cm. or less in length, round to oval, entire or slightly crenate, pubescent; flowers bluish lilac, nearly sessile, in dense axillary whorls.

This species, like the other mints, shows numerous variations. It grows on damp, gravelly places, especially by the borders of pools. It has a strong, peculiar odour resembling that of spearmint, but less agreeable; the taste is at first warm, aromatic and bitterish, followed by a cooling sensation (Guenther, III, 576; Mansfeld, 375; Bentley & Trimen, III, 201).

The herb is considered stimulant, carminative and emmenagogue. It is used in flatulence, nervous disorders and gout. It is used also as an insect repellent. Leaves, fresh or dried, are used as a flavouring for food, especially pudding (Hocking, 139; Muenscher & Rice, 114; De Wolf, loc. cit.).

M. pulegium yields (1–2%) a yellow or greenish yellow volatile oil (Pennyroyal Oil) with an aromatic taste and mint-like odour. The physico-chemical characteristics of oils from Spain and Morocco, which are the main sources of commercial oil, vary within the following limits: sp. gr.$^{15°}_{15°}$, 0.936–0.944; $n^{20°}$, 1.4829–1.4877; $[\alpha]_D$, +15.3° to +23.8°; pulegone, 85–96%; sol. in 4.5–5.5 vol. of 60% alcohol, clear to hazy with more. The oil contains pulegone, menthone, piperitone, piperitenone, menthol, *l*-α-pinene, *l*-limonene and dipentene. Steam-distillation of dried leaves from plants experimentally raised in Baramulla (Kashmir) gave 2.3% oil (sp. gr.$^{15°}$, 0.8925; $n^{20°}$, 1.483) (Guenther, III, 576–83; Merck Index, 700; Handa *et al.*, *Indian Perfum.*, 1957, **1**, 42).

Pennyroyal oil is used for scenting soaps and production of synthetic menthol. It is employed in medicine for the same purposes as the herb (Guenther, III, 585; Snell & Snell, 492).

M. rotundifolia (Linn.) Huds. APPLE MINT, ROUND LEAVED MINT

Bailey, 1949, 864; De Wolf, *Baileya*, 1954, **2**, 3, Fig. 3A.

A perennial, pubescent herb, 60–90 cm. high, native of Europe, probably cultivated in Indian gardens. Leaves sessile, generally conspicuously net-veined, rugose, roundish or elliptic, up to 10 cm. long, with crenate-serrate margins; flowers in dense axillary or terminal spikes, 5–10 cm. long.

This species, though not recorded so far in India, is widely grown. According to some authors, the plant has often been wrongly identified as *M. viridis*, though it does not bear lanceolate leaves, but only roundish or ovate orbicular leaves. This species is one of the putative parents of *M. spicata*. It has a delicate flavour, suggestive of apple, and can be used like other mints for flavouring food dishes and confectionery (Firminger, 138; Haines, IV, 741; Guenther, III, 586; De Wolf, loc. cit.; Muenscher & Rice, 111).

Steam-distillation of fresh tops yields 0.06–0.09% of an oil (sp. gr.$^{15°}$, 0.960–0.975; $[\alpha]^{15°}_D$, −24°; ester val., 101–133) consisting mainly of esters, free alcohols and small amounts of pinene and limonene. The principal constituent is piperitenone oxide (51%) which appears to be identical with the terpenic glyoxal from *M. spicata* (q.v.). The oil has no commercial importance (Guenther, III, 687; Reitsema, *J. Amer. chem. Soc.*, 1956, **78**, 5022).

M. spicata Linn. emend. Nathh. syn. *M. spicata* var. *viridis* Linn.: *M. viridis* Linn. SPEARMINT, GARDEN MINT, LAMB MINT

D.E.P., V, 231; Bailey, 1949, 863; De Wolf, *Baileya*, 1954, **2**, 3, Fig. 4A.

HINDI, BENG. & MAR.—*Pahari pudina, pudina.*

A glabrous perennial, 30–90 cm. high, with creeping rhizomes, indigenous to the north of England, but grown all over the world. It is cultivated in Indian gardens. Leaves smooth or nearly so, sessile, lanceolate to ovate, acute, coarsely dentate, smooth above, glandular below; flowers lilac, in loose, cylindrical, slender, interrupted spikes.

This species is very variable and is often erroneously recorded under the name *M. viridis*. It includes a number of forms whose identity and nomenclature are confusing. The species itself is considered to be a hybrid between *M. rotundifolia* and *M. longifolia*; cytological evidence indicates that the forms vary greatly in chromosome numbers and essential oil content (Purewal, 60; Firminger, 138; Gopalaswamiengar, 560; Guenther, III, 676; De Wolf, loc. cit.; Mansfeld, 373).

FIG. 125. MENTHA SPICATA—FLOWERING BRANCH

Spearmint is widely cultivated throughout the plains of India and used for culinary purposes. It thrives best in heavy loams well supplied with farmyard manure. It is usually propagated by planting divisions of old plants in rows 30 cm. apart, the distance between plants in the row being 15 cm. The field is weeded and watered during dry weather. The plants produce leaves for a number of years, but it is advisable to replant them annually in order to secure young and luxuriant growth (Purewal, 60; Roberts & Kartar Singh, 381).

Spearmint is affected by the rust, *Puccinia menthæ* Pers., which becomes active in spring. The rust is controlled by planting cuttings previously immersed in hot water at 115°F. for 10 minutes. *Rhizoctonia solani* Kuhn. causes leaf rot [Muenscher & Rice, 110; Sharma & Mahmud, *Nagpur agric. Coll. Mag.*, 1950–51, **25**(3–4), 23].

Green leaves of the plant are used for making chutney and for flavouring culinary preparations, vinegar, jellies and iced drinks. The herb is considered stimulant, carminative and antispasmodic. A soothing tea is brewed from the leaves and an alcoholic beverage (mint julep) is prepared from them and used as an antidote for poison. A sweetened infusion of the herb is given as a remedy for infantile troubles, vomiting in pregnancy and hysteria. The leaves are used in fevers and bronchitis (Muenscher & Rice, 110; De Wolf, loc. cit.; Kirt. & Basu, III, 1980; Caius, *J. Bombay nat. Hist. Soc.*, 1941–42, **42**, 401).

The leaves have a characteristic, aromatic odour and a slightly pungent taste, not followed by a cooling sensation as in the case of peppermint. Analysis of green leaves gave the following values: moisture, 83.0; protein, 4.8; fat (ether extr.), 0.6; carbohydrates, 8.0; fibre, 2.0; and mineral matter 1.6%; calcium, 200 mg.; phosphorus, 80 mg.; iron, 15.6 mg.; carotene (as vitamin A), 2,700 i.u.; nicotinic acid, 0.4 mg.; riboflavin, 80 μg.; and thiamine, 50 μg./100 g.; the leaves contain traces of copper (1.8 μg./g.) (U.S.D., 1955, 1303; *Hlth Bull.*, No. 23, 1956, 34; Bagchi & Chowdhury, *Ann. Biochem.*, 1949, **9**, 107).

The fresh flowering herb on distillation yields 0.25–0.50% of a volatile oil, known as Spearmint Oil. It is a colourless, yellow or greenish yellow liquid with the characteristic odour and taste of spearmint; the aroma improves on ageing. Table 4 gives the characteristics of spearmint oils obtained on an experimental scale at different places in India (U.S.D., 1955, 1304; Guenther, III, 679; Dhingra *et al.*, *Indian Perfum.*, 1957, **1**, 21).

TABLE 4—PHYSICO-CHEMICAL PROPERTIES OF SPEARMINT OILS

	Kanpur[1]	Kashmir[2]	Poona[3]
Sp. gr.	0.9349 (at 30°)	0.94 (at 18°)	0.9817 (at 30°)
$[\alpha]_D$	−57.4°	..	−97.8°
n	1.4948 (at 30°)	1.539 (at 18°)	1.4883 (at 27°)
Acid val.	9.3	0.30	0.66
Carvone, %	55.8	20	nil
Solubility in 80% alcohol	sol. in 1 vol.	sol. in 1–3 vol.	sol. in 1 vol. or more

[1] Dhingra *et al.*, *Indian Perfum.*, 1957, **1**, 21.
[2] Handa *et al.*, *J. sci. industr. Res.*, 1957, **16A**(5), suppl., 17.
[3] Chakravarti & Bhattacharyya, *Perfum. essent. Oil Rec.*, 1954, **45**, 217.

The characteristic constituent of the oil is *l*-carvone. Oil distilled at Kanpur contained: carvone, 55.8; terpenes (chiefly *l*-limonene and dipentene), 17.5; alcohol (as dihydrocarveol), 6.7; and esters (as dihydrocarveol acetate), 11.6%. A sample of oil distilled from plants grown in Poona contained no carvone: a terpenic glyoxal, $C_{10}H_{14}O_2$, was the principal constituent (54%): other constituents of the oil were cineole (31.4%) and traces of α-pinene, phellandrene, and dihydrocarveol and its ester. The differences in the composition of oils are evidently due to varietal or even specific variations (Guenther, III, 681, 683; Dhingra *et al.*, loc. cit.; Chakravarti & Bhattacharyya, *Perfum. essent. Oil Rec.*, 1954, **45,** 217; 1955, **46,** 256).

Spearmint Oil produced in U.S.A. is derived mainly from Scotch Mint (*M. cardiaca* Gerard ex Baker) a species closely related to *M. gentilis* and considered to be a hybrid of *M. arvensis* and *M. spicata*. Russian oil is obtained probably from *M. verticillata* Linn. var. *strabala* Briq.: it contains: linalool, 50–60; cineole, 20; and carvone, 5–10% (Hocking, *J. Amer. pharm. Ass., sci. Edn*, 1949, **38,** 394; Guenther, III, 676, 683).

Spearmint oil is used in U.S.A. for flavouring chewing gums, tooth pastes, confectionery and pharmaceutical preparations. The oil has not attained any commercial importance in India [Guenther, III, 682; Dhingra *et al.*, loc. cit.; Handa *et al.*, *J. sci. industr. Res.*, 1957, **16A**(5), suppl., 17].

MENYANTHES Linn. (*Gentianaceae*)

A small genus of herbs native of north temperate and sub-arctic zones. One species is recorded in India.

M. trifoliata Linn. BOG BEAN, BUCK BEAN

D.E.P., V, 232; Fl. Br. Ind., IV, 130; Kirt. & Basu, Pl. 642B.

A perennial aquatic herb with creeping or floating rootstocks reported to occur in Kashmir. Leaves trifoliate: leaflets elliptic or oblong-obtuse, entire or obscurely wavy; flowers white or bluish, in racemes at ends of long scapes; capsules globose, with numerous lenticular, smooth, shining, yellow seeds.

The whole plant, particularly leaves and rhizomes, is bitter in taste and resembles gentian (*Gentiana lutea*) in properties. The plant contains rutin, quercetin-3-galactoside, kaempferol-3-galactoside and a bitter glucoside, meliatin, which is identical with loganin ($C_{17}H_{26}O_{10}$, m.p. 223°); an alkaloid gentianine ($C_{10}H_9O_2N$, m.p. 79–80°) found in gentian, a saponin, a tannin (3%), a yellow colouring matter and a small amount (0.07%) of volatile oil are also present. The leaves contain ascorbic acid (204.7 mg./100 g.). The rootstock contains loganin, tannin and betulinic acid (a triterpene hydroxy acid, $C_{30}H_{48}O_3$, m.p. 316–18°) (Wehmer, II, 975; *Biol. Abstr.*, 1959, **33,** 1891; Birch & Smith, *Aust. J. Chem.*, 1956, **9,** 234; Manske & Holmes, V, 310; *Chem. Abstr.*, 1941, **35,** 3033; 1947, **41,** 4616; 1953, **47,** 7040; Heilbron & Bunbury, I, 287; III, 186).

The plant is regarded as an emergency food in Russia. Leaves are used as a substitute for hops in the manufacture of beer in Germany and Sweden. The plant is considered tonic, febrifuge and deobstruent; in large doses, it is cathartic, emetic and diaphoretic. It is used in rheumatism, gout, dropsy, scurvy and skin affections; it is also used as a substitute for tea. The plant is used as a narcotic in China (Uphof, 236; Bailey, 1947, II, 2037; Chittenden, III, 1287; Kirt. & Basu, III, 1670; Gathercoal & Wirth, 196; Wren, 52; Bentley & Trimen, III, 184; Roi, 407).

MERIANDRA Benth. (*Labiatae*)

A small genus of hoary or woolly shrubs found in India and East Africa. Two species are recorded in India of which one is exotic and grown in gardens.

M. bengalensis Benth. BENGAL SAGE

D.E.P., V, 235; Fl. Br. Ind., IV, 653; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 104; Kirt. & Basu, Pl. 762A.

HINDI & BENG.—*Kafurkapat*; TEL.—*Sima-karpuramu* (names applied to leaves).

A large straggling shrub, native of Ethiopia, sometimes cultivated in gardens, especially in Bengal. Leaves oblong-lanceolate, finely crenulate, aromatic; flowers white, in globose whorls; nutlets usually solitary, obovate-oblong, pale brown, smooth.

M. bengalensis is propagated by division of roots. It resembles the common sage (*Salvia officinalis* Linn.) in appearance and is often mistaken for it. Dried leaves of the plant have a fragrant odour and a warm, bitterish, aromatic and grateful taste; they are used as condiment with curries in Bengal. They are considered tonic, carminative, astringent and antiseptic. An infusion of leaves is used as a gargle in sore throat and as mouth wash in aphthae. It arrests or diminishes milk secretion. A tea is prepared from the leaves and used in fevers and as stomachic. The leaves are placed along with stored

clothes to repel insects (Firminger, 138 : Nadkarni, I, 792 ; Kirt. & Basu, III, 1996 ; Cooke, II, 475).

The herb on distillation yields 0.4–1.5% of a volatile oil (Oil of Meriandra) used in Ethiopia for the same medicinal purposes as sage oil. When the oil is cooled, camphor separates out. Partially decamphorated oil (from Ethiopia) has the following characteristics: $d^{15°}$, 0.9464 ; $n_D^{20°}$, 1.4718 ; $[\alpha]_D$, - 0.5° ; acid val., 1.0 ; ester val., 11.8 ; sol. in 1.8 or more vol. of 70% alcohol. The principal constituent of the oil is camphor (up to 70%) ; cineole, camphene and another terpene are present (Finnemore, 727 ; Parry, I, 268 ; *Chem. Abstr.*, 1955, **49**, 11245 ; 1958, **52**, 14979).

M. strobilifera Benth. (names in Indian languages same as those of *M. bengalensis*) is an erect shrub, 0.6–1.5 m. high, found on dry rocks in western temperate Himalayas from Simla to Kumaon at altitudes of 1,500–2,100 m. It possesses the same properties as those of *M. bengalensis*. A strong decoction of the leaves is used as lotion for ulcers and for healing raw skin abrasions (Kirt. & Basu, III, 1996).

MERREMIA Dennst. (*Convolvulaceae*)

A genus of climbing, prostrate or erect herbs or low shrubs distributed in the tropics. About a dozen species occur in India ; a few exotics are grown in gardens.

M. dissecta (Jacq.) Hallier f. syn. *Ipomoea sinuata* Ort.

Fl. Br. Ind., IV, 214 ; Fl. Malesiana, Ser. I, **4**(4), 448.

A perennial twining shrub, native of tropical America, occasionally grown in gardens for ornament and sometimes found as an escape in hedges and moist places. Leaves deeply palmately 5–7-lobed ; flowers funnel-shaped, white with purple centre ; capsules globose with 4 glabrous, black seeds.

The plant is reported to contain hydrocyanic acid and is poisonous to cattle. The leaves possess the odour of oil of bitter almonds and are used in the preparation of a liqueur (Chopra *et al.*, 708 ; Williams & Williams, 195 ; Dymock, Warden & Hooper, II, 540).

M. emarginata (Burm. f.) Hallier f. syn. *Ipomoea reniformis* Choisy

D.E.P., IV, 491 ; Fl. Br. Ind., IV, 206 ; Fl. Malesiana, Ser. I, **4**(4), 444 ; Kirt. & Basu, Pl. 665B.

SANS.—*Mushakarni* ; HINDI—*Musakani* ; BENG.—*Bhuikamri, indurkani* ; TEL.—*Elika-jemudu* ; TAM.—*Elikathu keerai*.

BOMBAY—*Undirkani*.

A perennial, much-branched, prostrate herb found in damp places in upper Gangetic plain, Bihar, West Bengal, N. Circars, Madras, western ghats, Deccan and Gujarat ascending to 900 m. in the hills. Leaves reniform or ovate-cordate, crenate ; flowers tubular-campanulate, yellow ; capsules small, sub-globular with 4 seeds.

The plant is eaten as pot-herb. It is considered deobstruent, diuretic and alterative, and used in rheumatism and neuralgia. In Java, it is used for coughs. The juice of the plant is dropped into the ear to cure sores (Kirt. & Basu, III, 1722 ; Chopra, 1958, 511 ; Burkill, II, 1455).

M. tridentata (Linn.) Hallier f. subsp. **tridentata** syn. *Ipomoea tridentata* Roth

Fl. Br. Ind., IV, 205 ; Fl. Malesiana, Ser. I, **4**(4), 445, Fig. 27.

SANS.—*Prasarini* ; TAM.—*Mudiya kunthal, thirippan pullu, savulikodi* ; MAL.—*Prasarini, talanili*.

MUNDARI—*Daru jamjuri, but rede, but tasad*.

A slender, much-branched, prostrate perennial found in upper Gangetic plain, Bihar, Orissa (near Chilka lake), West Bengal, S. India, Deccan and Gujarat. Leaves linear-hastate or oblong-obovate, often deeply emarginate ; flowers funnel-shaped, pale yellow ; capsules small, globose with 2–4 seeds.

The plant is relished by cattle. It is considered bitter, astringent, calefacient and tonic and used in the treatment of rheumatism, hemiplegia, piles, swellings and urinary disorders ; a decoction of the root is also used for the same purposes (Chandrasekharan & Sundararaj, *Madras agric. J.*, 1949, **36**, 431 ; Mooss, pt I, 81, 83 ; Kirt. & Basu, III, 1734 ; Rama Rao, 279).

M. tridentata subsp. *hastata* (Desr.) Ooststr. syn. *M. hastata* Hallier f. ; *Ipomoea angustifolia* C. B. Clarke (Fl. Br. Ind.), non Jacq. (TEL.—*Konda, sita savaram* ; TAM.—*Tala-neli* ; MAL.—*Cheruvayera*) is a diffuse, twining biennial found in upper Gangetic plain, West Bengal, Khasi and Jaintia hills, Orissa (near Chilka lake), east and west coast districts, Deccan and Rajasthan. A poultice of leaves is applied to the head for fever in Malaya. A decoction of the roots is used as mouth wash for toothache (Burkill, II, 1456 ; Fox, *Philipp. J. Sci.*, 1952, **81**, 341).

M. tuberosa (Linn.) Rendle syn. *Ipomoea tuberosa* Linn.

Bailey, 1949, 820; Fl. Malesiana, Ser. I, **4**(4), 447, Fig. 29.

A glabrous perennial twiner with a large subterranean tuber, probably native of tropical America, grown in Indian gardens; it is also found as an escape. Leaves orbicular, deeply palmately 7-lobed; flowers funnel-shaped, yellow; capsules sub-globose to depressed globose with 4 seeds.

The tuberous root, known as Brazilian Jalap, is a drastic purgative. It occurs in the form of transverse, circular slices, 5–8 cm. in diam. × 0.5–1.0 cm. thick, pale greyish brown in colour with several concentric rings and numerous pale resin cells. It contains 12–25% resin (acid val., 23.1; sap. val., 141.6) of which 5–6% is soluble in ether; this resin is more soluble in water and chloroform than jalap resin. It is used as an adulterant of jalap (*Exogonium purga*) (B.P.C., 1959, 392; Kirt. & Basu, III, 1728; Wallis, 431).

M. umbellata (Linn.) Hallier f. subsp. **orientalis** (Hallier f.) Ooststr. syn. *Ipomoea cymosa* Roem. & Schult.; *I. pilosa* Houtt.

D.E.P., IV, 484; Fl. Br. Ind., IV, 211; Fl. Malesiana, Ser. I, **4**(4), 449.

Beng.—*Sapussundu*; Tel.—*Catukattutivva, kappativva, verumalle*; Tam.—*Kolavarvalli*; Mal.—*Kolavara valli*; Oriya—*Paninoi*.

Assam—*Goria loti, kolia lota*; Garo—*Sithribodu*; Lushai—*Voktesentil*; Santal—*Karmbi arak*.

A twining or prostrate herb found from Punjab eastwards to Assam, Garo, North Cachar, Aka and Lushai hills, eastern ghats up to Godavari, western ghats, Deccan and Andaman Islands ascending to 1,200 m. in the hills. Leaves variable, ovate, ovate-oblong or oblong, entire; flowers funnel-shaped, white or yellow to orange; capsules globose with 4 hairy seeds.

FIG. 126. MERREMIA UMBELLATA SUBSP. ORIENTALIS—FLOWERING BRANCH

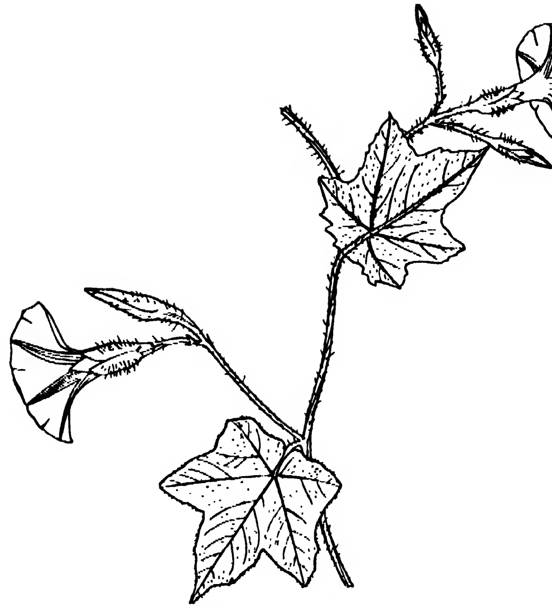


FIG. 127. MERREMIA VITIFOLIA—FLOWERING BRANCH

The young leaves are eaten as pot-herb. The plant is considered useful in Indonesia for fistulae, pustules and tumours. A poultice of the leaves is used as an external application for burns, scalds and sores. The seeds yield a mucilage used as an aperient and alterative in cutaneous diseases. The seeds contain also a fatty oil and a resin [*J. sci. Res. Indonesia*, 1952, **1** (suppl.), 28; Burkill, II, 1456–57; Nadkarni, I, 685–86; Wehmer, II, 1012].

M. vitifolia (Burm. f.) Hallier f. syn. *Ipomoea vitifolia* Blume

D.E.P., IV, 496; Fl. Br. Ind., IV, 213; Fl. Malesiana, Ser. I, **4**(4), 448; Bor & Raizada, 7, Fig. 6.

Mar.—*Navalicha vel.*

Bombay—*Nawal*; Mundari—*Nanrikadsom ba*; Garo—*Dukhumi-bidu*.

A large perennial herbaceous twiner found almost throughout India, except the dry North-West, ascending to 1,200 m. in the hills. Leaves suborbicular or broadly ovate, palmately 5–7-lobed; flowers funnel-shaped, yellow or purplish; capsules subglobose with 4 seeds.

The plant is propagated by stem cuttings or layers; it grows fast and is suitable for covering walls, trellises and pergolas (Bor & Raizada, 7).

The plant is used for strangury and urethral discharges. The juice of the plant is considered cooling and diuretic. The leaves contain a glycoside, which on hydrolysis yields hydrocyanic acid and benzaldehyde. The root is eaten raw by Mundas as a stomachic (Kirt. & Basu, III, 1733; Wehmer, II, 1014).

M. aegyptia (Linn.) Urban syn. *Ipomoea pentaphylla* Jacq. (Delhi—*Ghiabel*) is a herbaceous twining annual found from upper Gangetic plain through Rajasthan and Madhya Pradesh to S. India. The seeds of the plant are considered edible (Fl. Delhi, 246).

M. hederacea (Burm. f.) Hallier f. syn. *Ipomoea chryseides* Ker-Gawl. is a twining or prostrate herb found more or less throughout India. The plant is eaten by animals. A poultice of the leaves is applied to chapped hands and feet (Burkill, II, 1456).

M. mammosa (Lour.) Hallier f. syn. *Ipomoea gomezii* C.B. Clarke is a large climber found in Lakhimpur (Assam) and Andaman Islands. The tubers are edible; they are used locally in the treatment of diabetes and in affections of throat and respiratory organs; they are reported to be mildly purgative [Burkill, II, 1455; Fl. Malesiana, Ser. I, **4**(4), 451].

M. rhyncorhiza (Dalz.) Hallier f. syn. *Ipomoea rhyncorhiza* Dalz. is a twiner found in Konkan, Kanara and Kerala. The tubers of the plant are eaten; leaves are used as vegetable (Cooke, II, 239).

MESEMBRYANTHEMUM Linn. (*Aizoaceae*)

A large genus of succulent perennial, rarely annual herbs, sometimes subshrubs distributed mostly in S. Africa; a few species are reported from Australia, New Zealand, Arabia, Mediterranean region, Canary Islands and California. Some of them are grown in Indian gardens.

The genus has been recently split into a number of genera and the species grown in Indian gardens are now assigned to genera other than *Mesembryanthemum* (Bailey & Bailey, 475; Chittenden, III, 1290).

Mesembryanthemum spp. occur in hot or semi-arid regions, barren rocky places and sandy plains; a few species frequent sea coasts. They can be grown in rockeries; some are suitable for borders, window gardens and hanging baskets. They are propagated by seeds or cuttings. Seeds are sown in October in the plains and in March on the hills. Watering should be so done that only the ground, not the plants, is wetted (Bailey, 1947, II, 2040; Bailey & Bailey, 475; Gopalaswamiengar, 400; Chittenden, III, 1290–91; Firminger, 503–04).

M. crystallinum Linn. = *Cryophytum crystallinum* (Linn.) N.E. Br. ICE PLANT

D.E.P., V, 236; Bailey, 1947, II, 2042, Fig. 2367.

An annual succulent, native of S. Africa, grown in Indian gardens for its foliage. Leaves fleshy, ovate or long-spathulate, usually clasping, covered with glistening papillae; flowers small, whitish or light rose.

M. crystallinum is grown, in America, on the sea coast and salty deserts to remove excess salts from the soil. Its introduction into the saline areas of Punjab has been recommended as a reclamation measure (Malhotra, *Indian For.*, 1952, **78**, 509).

The plant contains appreciable amounts of malic, oxalic, citric and phosphoric acids; it is reported to contain a saponin and an alkaloid, mesembrine (?). It yields up to 30–50% ash (dry basis) containing c. 50% potash (Wehmer, I, 299; Watt & Breyer-Brandwijk, 47).

The leaves of the plant are eaten as spinach and salad; seeds are edible. The plant is considered demulcent and diuretic, and used in inflammations of pulmonary and genito-urinary mucous membrane. Leaves are used in ascites, dysentery and diseases of the liver and kidney (Uphof, 236; Steyn, 210; U.S.D., 1947, 1519; Watt & Breyer-Brandwijk, 47).

Mesquite Bean — *see* **Prosopis**

Mesta — *see* **Hibiscus**

MESUA Linn. (*Guttiferae*)

A genus of trees or shrubs distributed chiefly in tropical Asia. One species is found in India.

M. ferrea Linn.

D.E.P., V, 236; Fl. Br. Ind., I, 277.

HINDI & BENG.—*Nagkesar, nagesar*; GUJ. & MAR.—*Nagchampa*; TEL.—*Nagkesara, kesaramu, nagachampakamu*; TAM.—*Nangu, nangal, irul, nagachambagam*; KAN.—*Nagakesara, nagasampige*; MAL.—*Nanga, peri, veluthapala*.

ASSAM—*Nahor, dieng-ngai, ngai-ching*; ANDAMANS—*Gangane*.

TRADE—*Mesua*.

A medium-sized to large evergreen tree with short trunk, often buttressed at the base, found in the Himalayas from Nepal eastwards, in north-eastern India, Deccan Peninsula and the Andaman Islands, ascending to an altitude of 1,500 m. Bark greyish or reddish brown, exfoliating in large thin flakes; leaves lanceolate, coriaceous, generally covered with a waxy bloom underneath, red when young; flowers large, solitary or in clusters of 2–3, white, fragrant; fruits ovoid, nearly woody, 2.5–5.0 cm. long, with persistent calyx; seeds 1–4, dark brown, up to 2.5 cm. diam.; cotyledons fleshy, oily. The tree is cultivated in gardens and avenues for its flowers and foliage which are attractive, particularly when young.

Mesua is found in moist evergreen or semi-evergreen forests, either scattered or in more or less pure patches or belts. It requires well drained, deep fertile soil; stiff clay and low lying situations are unsuitable. It is a strong shade bearer, particularly when young, and this makes it a valuable component of the middle storey in forests. It is susceptible to frost and drought, but these conditions are practically unknown in its natural habitat (Troup, I, 24–26; Kadambi, *Indian For.*, 1954, **80,** 531).

Natural reproduction is generally profuse on account of abundant seeding. Artificial propagation may be done by direct sowing or by transplanting nursery raised seedlings. Transplanting is preferable under top canopy shade and may be carried out from the first to the third rainy season after sowing. A spacing of 6 ft. is recommended. The rate of growth is slow. The exploitable girth of *c.* 6 ft. is attained in 90 years or more, indicating a mean annual girth increment of *c.* 1 in. It is likely that the tree grows faster in plantations than in natural forests. Mesua forests are worked under selection or shelterwood methods (Troup, I, 26–28; Kadambi, loc. cit.).

The tree is affected by brown cubical rot (*Fomes dochmius* Berk. & Br.) and white sap and heart rot [*Ganoderma lucidum* (Leyss.) Karst.]. It is also attacked by beetles, *Xyleborus discolor* Blandford, *X. interjectus* Blandford and a few others as well as

Indian Oilseeds Comm., Hyderabad

FIG. 128. MESUA FERREA—PLANTED AVENUE

FIG. 129. MESUA FERREA—FLOWERING AND FRUITING BRANCH

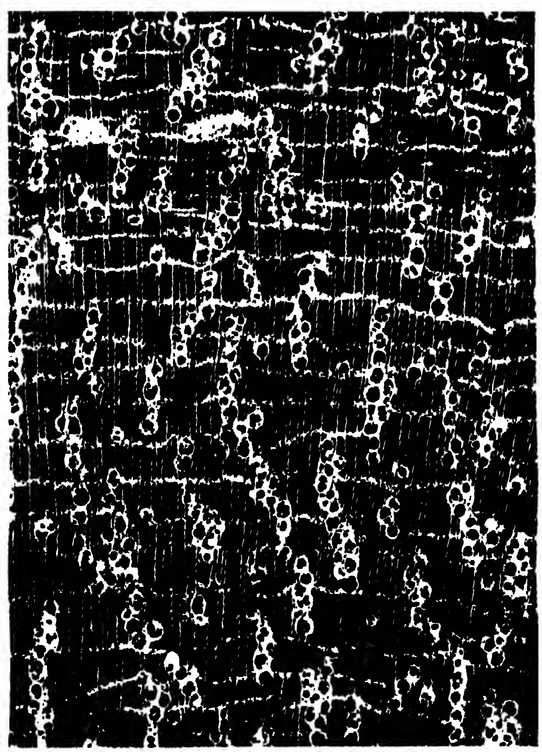
by a buprestid borer, *Chrysochroa* sp. (*Indian J. agric. Sci.*, 1950, **20,** 126 ; Khan, *Pakist. J. Sci.*, 1952, **4,** 65 ; Stebbing, 587–88 ; Mathur, *Indian For.*, 1958, **84,** 40).

The sapwood is creamy white or pinkish brown, rather broad ; heartwood dark red or deep reddish brown, smooth, straight- or somewhat interlocked-grained, medium- to coarse-textured, hard, strong, tough and heavy (sp. gr., 1.03 ; wt., 56–67 lb./cu. ft.). The timber is slow and difficult to season and is liable to surface cracking, warping and splitting. Slow drying under cover, protection from hot winds and weighting of stacks prevent excessive degrade. The wood is very durable ; graveyard tests indicate a life of 10–15 years ; it is rarely attacked by white ants. It is refractory to treatment, side and end penetration being practically nil (Pearson & Brown, I, 58–59 ; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** 54 ; Trotter, 1944, 136 ; Browne, 192 ; Purushotham *et al.*, *Indian For.*, 1953, **79,** 49).

The wood is difficult to saw even when green. It can be worked by tools and machines, but is liable to tear up in rough streaks if worked on a quartered surface. The data for the comparative suitability of mesua timber, expressed as percentages of the same properties of teak, are: wt., 140 ; strength as a beam, 145 ; stiffness as a beam, 150 ; suitability as a post, 150 ; shock-resisting ability, 160 ; retention of shape, 55 ; shear, 145 ; and hardness, 215 (Pearson & Brown, I, 60 ; Trotter, 1944, 135 ; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** Sheet No. 13).

Mesua timber is used for railway sleepers, bridges and posts, beams and construction work ; it is suitable for electric poles and currier's cutting blocks. It is used also for boat-building (especially keels, helms and masts), well-construction, mines, agricultural implements, crushers, bearings, tool handles, golf club heads and walking sticks. It may be used for gunstocks, musical instruments and cabinet work, although rather heavy for these purposes. It is a good fuelwood (calorific value: *sapwood*– 4,956 cal., 8,921 B.t.u. ; *heartwood* –5,051 cal., 9,090 B.t.u. The wood shows marked Russel effect that is, it acts on photographic emulsions in total darkness giving clear and sharp pictures of grain structure and surface markings (Pearson & Brown, I, 60 ; Trotter, 1944, 135 ; Howard, 366 ; *Industry, Calcutta*, 1950–51, **41,** 299 ; Limaye *Indian For. Leafl.*, No. 8, 1941 ; Kadambi, loc. cit. ; Browne, 192 ; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 20).

Seed kernels, forming 53–73% of the weight of seeds (150–200 seeds weigh 1 lb.), yield 60–77% of a viscous, reddish or dark brown oil with a disagreeable odour and a bitter taste. On standing, the oil deposits stearin and resinous matter. A specimen of



F.R.I., Dehra Dun. Photo : S. S. Ghosh

FIG. 130. MESUA FERREA—TRANSVERSE SECTION OF WOOD (× 10)

oil from Assam had the following characteristics: $d_{27°}^{27°}$, 0.9598 : $n_D^{27°}$, 1.4780 ; iod. val., 88.36 ; sap. val., 208.6 ; acid val., 6.08 ; R.M. val., 4.81 ; Polenske val., 0.52 ; Hehner val., 90.41 ; and unsapon. matter, 2.92%. The fatty acid composition of the oil was: myristic, 0.22 ; palmitic, 13.58 ; stearic, 13.24 ; oleic, 59.09 ; and linoleic, 13.88 mol.% ; the component glycerides were: trisaturated, 6.39 ; palmitostearo-olein, 6.12 ; dipalmito-olein, 6.09 ; distearo-olein, 6.12 ; stearo-diolein, 12.57 ; palmito-diolein, 12.69 ; linoleo-diolein, 28.53 ; and triolein, 21.47 mol.%. Wide variations have been observed in the physico-chemical characteristics of oils from different localities ; iod. val. ranges from 73 to 96, acid val., 6 to 31, and sap. val., 193 to 230 (Troup, I, 25 ; Dhingra & Hilditch, *J. Soc. chem. Ind., Lond.*, 1931, **50**, 9 T ; Kasturi *et al.*, *J. sci. industr. Res.*, 1954, **13B**, 453 ; Kapadia & Aggarwal, ibid., 1954, **13B**, 732 ; Eckey, 690 ; Dutt *et al.*, *Indian Soap J.*, 1950–51, **61**, 72).

The seed oil is suitable for soap making, but has not been exploited for this purpose because of its objectionable colour. The oil can be refined by treatment with caustic soda followed by bleaching with activated carbon, or treatment with potassium chlorate and hydrochloric acid. The non-glyceridic components may be extracted with alcohol or other solvent, and the oil treated with dilute alkali, followed by bleaching and deodorization. An elegant refining method consists in dissolving the oil in 5 times its weight of carbon tetrachloride and passing the solution through a column of alumina ; the column is subsequently washed with carbon tetrachloride and the solution and washings when worked up yield a refined product which is colourless, odourless and tasteless. Refined oil is suitable for use as soap stock (Datta *et al.*, *Bull. Dep. Ind. Beng.*, No. 60, 1933 ; Kapadia & Aggarwal, loc. cit. ; Gupta, *J. sci. industr. Res.*, 1951, **10B**, 24 ; Mitra, *Indian Soap J.*, 1954 55, **20**, 100 ; Kasturi *et al.*, loc. cit.).

It is estimated that c. 150,000 md. (5,500 tons) of mesua seeds are annually available from Lakhimpur and Sibsagar districts of Assam. Efforts are being made to establish a factory to extract the oil for use in the manufacture of soap [*Oils & Oilseeds J.*, 1958–59, **11**(3), 12 ; 1959–60, **12**(1), 17].

Mesua seed contains a pale yellow lactone, mesuol ($C_{23}H_{22}O_5$, m.p. 154°), to the extent of 1% ; it is probably a 4-phenylcoumarin of a complex nature. The seed contains also another phenolic constituent, mesuone ($C_{24}H_{42}O_4$, m.p. 136°) in much smaller concentration. Both mesuol and mesuone show anti-bacterial activity against *Micrococcus pyogenes* var. *aureus*, *Escherichia coli*, *Eberthella typhosa*, *Vibrio cholerae*, *Bacillus friedlanderi* and *Mycobacterium phlei*. Mesuol is more active than mesuone and the activities of both are markedly depressed in the presence of normal serum. Mesuol is as active as allicin and c. 1% as active as penicillin G against *M. pyogenes* var. *aureus*. The kernel oil shows slight anti-bacterial activity against *M. pyogenes* var. *aureus* and the shell oil is inactive (Dutt *et al.*, *J. Indian chem. Soc.*, 1940, **17**, 277 ; Chakraborty *et al.*, *Proc. nat. Inst. Sci. India*, 1959, **25B**, 8).

The kernel meal, freed from oil, is rich in nitrogen (5.1%) and phosphorus and may be used as manure (Mitra, loc. cit. ; Datta *et al.*, loc. cit.).

The fragrant stamens of mesua flowers are reported to be used in Malaya for stuffing pillows and cushions. Dried flowers, along with other aromatics are used in the preparation of perfumed ointments. The flower buds contain a yellow colouring matter and two bitter poisonous substances. A reddish brown volatile oil (d^{21}, 0.891) with the characteristic aroma of the flowers is obtained by solvent extraction of flowers or distillation with water ; it may also be obtained by enfleurage with olive oil. Known under the name otto of *nagkeshar*, the oil is used for perfuming soaps, particularly in conjunction with sandalwood oil [Burkill, II, 1460 ; *Chem. Abstr.*, 1931, **25**, 3839 ; Wehmer, II, 784 ; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(4), suppl., 49 ; *Chem. Abstr.*, 1948, **42**, 3535].

The oleo-resin, which exudes from the base of immature fruits and also from incisions in bark and roots, has a strong aromatic odour. It yields 0.6% of a volatile oil with the characteristic odour of flowers. The oleo-resin has been suggested as a substitute for Canada balsam ; it may be diluted with turpentine and used as a varnish.

The fruit is sometimes eaten. The pericarp contains a considerable amount of tannin. The flowers are astringent and stomachic. Bark and unripe fruits are astringent, aromatic and sudorific. The seed oil is used as an embrocation in rheumatism and for skin diseases (Kirt. & Basu, I, 275).

METROXYLON Rottb. (*Palmae*)

D.E.P., V, 239 ; VI (2), 383 ; Fl. Br. Ind., VI, 481 ; Blatter, 256, Pl. 48 & 49.

A small genus of palms found mainly in Malaysia. Two species, *M. sagu* Rottb. and *M. rumphii* Mart. commonly known as Sago Palms, constitute the

principal source of sago. They are occasionally grown in Indian gardens.

M. sagu Rottb. is an unbranched palm, about 9–12 m. high, indigenous to Malaya, and often grown in Indonesia and the Philippines. It has a thick-set cylindrical trunk, often attaining a girth of 1.25–1.50 m. The palm flowers once in its life time at the age of 10–15 years after which it dies.

The palm thrives in low marshy situations and is propagated by suckers. It can also be grown from seeds, though good viable seeds are difficult to obtain; seedlings raised from them do not develop true to type; some are smooth sheathed and some are spiny sheathed, indicating that the cultivated palm is a hybrid of *M. sagu* (smooth sheaths) and *M. rumphii* (spiny sheaths).

Sago palm attains maturity and produces an inflorescence at the age of 9–15 years, when the interior of the stem is gorged with starch. The palm is felled at this stage and the stem cut into short lengths of 1.0–1.2 m. and split. The pith is rasped into a coarse meal and kneaded with water over a strainer through which the starch passes into a trough leaving the fibre behind. The starch is allowed to settle, washed once or twice with water and dried. The quality of starch improves with washing. Starch of high quality is used for preparing sago pearls. For this purpose, the starch is kneaded into a paste and rubbed into grains through a sieve. The grains are roasted over fire in a pan smeared with vegetable oil to give gelatinized globules. A single palm is reported to yield 250–660 lb. of sago; on rare occasions a yield as high as 1,200 lb. is obtained (Blatter, 259; Burkill, II, 1461; Grist, 299–301; Johnson & Raymond, *Colon. Pl. Anim. Prod.*, 1956, **6**, 20).

Sago globules are used chiefly as an article of diet, especially during convalescence and also in bowel complaints and febrile disorders. It is non-irritating to the stomach lining and is readily digested. Sago starch is used in puddings and as a component of bread, pastries and various other food products. Sago starch is used in the textile industry for sizing and finishing cotton warps. It gives a solution with a higher viscosity than maize starch solution of the same concentration, though not so high as that of tapioca starch; the viscosity is maintained over a wide range of temperature (Brautlecht, 276; Steinmetz, II, 395; Brown, I, 220; Johnson & Raymond, loc. cit.).

Granules of sago starch are fairly large (20–60μ) in size and oval in shape. Analysis of a sago gave the following values: moisture, 12.2; protein, 0.2; fat, 0.2; carbohydrates (starch), 87.1; and mineral matter, 0.3%; calcium, 10; phosphorus, 10; iron, 1.3; and nicotinic acid, 0.2 mg.% (Wurzburg, *Econ. Bot.*, 1952, **6**, 211; *Hlth Bull.*, No. 23, 1951, 56).

The fresh pith of sago palm is toasted and eaten in the Philippines. The pith meal is valued as a feed for pigs and also for horses and poultry. It can replace a part of barley meal in pig rations. Analysis of pith meal and sago refuse gave the following values: *pith meal*—moisture, 22.7; protein, 2.1; fat, 0.2; carbohydrates, 51.0; fibre, 7.8; and mineral matter, 16.2%; digestible protein, 1.4; digestible carbohydrates, 50.5; and starch equiv., 64.2 lb./100 lb.; nutritive ratio, 45.0; *sago refuse*—moisture, 73.5; protein, 0.5; fat, 0.1; carbohydrates, 23.5; fibre, 1.6; and mineral matter, 0.8%; digestible protein, 0.3; digestible carbohydrates, 20.1; and starch equiv., 21.5 lb./100 lb.; nutritive ratio, 70.7 (Brown, I, 220; Teik, *Sci. Ser. Dep. Agric., Malaya*, No. 24, 1951, 22, 26, 71, 72; Burkill, II, 1462).

The outer layers of the trunk are used for flooring and also for making buckets. The leaves are used for thatching, mats and baskets (Brown, I, 220–22; Burkill, II, 1463).

Sago was formerly imported into India from Malaya and Indonesia. It is now obtained mainly from *Manihot esculenta* (Cassava) cultivated in India.

Mexican Jalap — *see* **Exogonium**

Mexican Poppy — *see* **Argemone**

Mexican Tea — *see* **Chenopodium**

MEYNA Roxb. ex Link (*Rubiaceae*)

A genus of shrubs or small trees distributed in the tropical and sub-tropical regions of the Old World. Two or three species are found in India.

Vangueria spinosa of Fl. Br. Ind. covers a group of plants which are not discriminated in their economic uses. Recently these have been separated and transferred to several species of *Meyna* including *M. laxiflora* and *M. spinosa*; these species, however, are considered almost inseparable by some.

M. laxiflora Robyns syn. *Vangueria spinosa* Hook. f. (Fl. Br. Ind.) in part

D.E.P., VI (IV), 221; Fl. Br. Ind., III, 136.

HINDI & BENG.—*Muyna, muduna, mainphal, mainakanta*; MAR.—*Alu, huloo, halaweni*; GUJ.—*Alu, atu*; TEL.—*Cegagadda, veliki, visikilamu*;

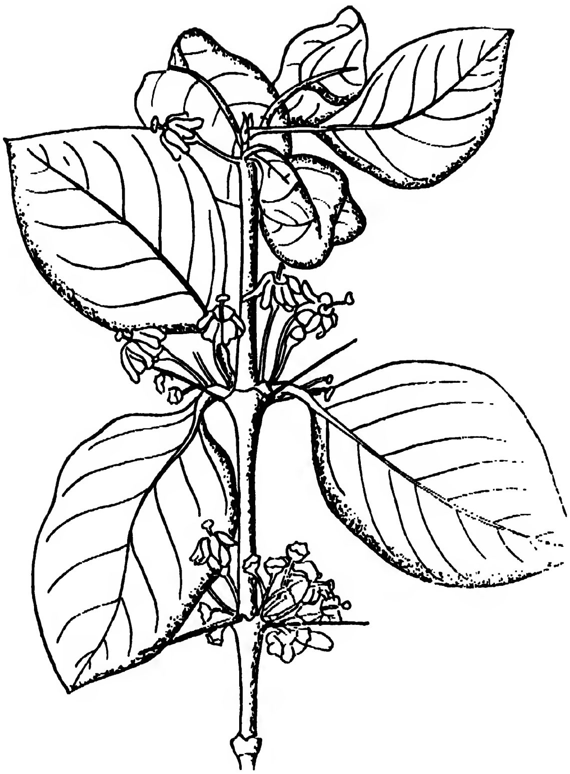


FIG. 131. MEYNA LAXIFLORA—FLOWERING BRANCH

TAM.—*Manakkarai*; KAN.—*Mullakare, gundkare, gobergally*; ORIYA - *Gurbeli, moltakanta.*

ASSAM—*Ketkora, mon.*

A spinescent or unarmed shrub or a small tree found in western U.P., Bengal, Assam and the Deccan Peninsula. Leaves ovate to elliptic; flowers in lax cymes, greenish white; drupes sub-globose, *c.* 2.5 cm. diam., smooth, green to brown, succulent; seeds albuminous, with a membranous testa. The closely related *M. spinosa* Roxb. ex Link bears flowers crowded into fascicles, and has shorter pedicels and petioles.

The fruit and the leaves are eaten. The leaves are used as fodder, but are of a poor quality (Fl. Assam, III, 67; Haines, IV, 439; Laurie, *Indian For. Leafl.*, No. 82, 1945, 17).

The dry fruit is believed to be narcotic and is reported to be used for boils and dysentery. The powdered leaves are said to be good for diphtheria [Bressers, 77; Carter & Carter, *Rec. bot. Surv. India*, 1921, **6**(9), 415].

The decorticated seeds on extraction with benzene yield 38.5% of a fat having the following characteristics: gr. 0.9515; m.p. 50°; 1.4780; acid val., 3.9; sap. val., 190.75; iod. val., 88.63; R.M. val., 1.56; Polenske val., 0.48; acet. val., 5.8; and unsapon. matter, 0.95%. The component fatty acids of the oil are: palmitic, 18.8; stearic, 9.0; oleic, 32.5; and linoleic, 39.7% (Nadkarni *et al.*, *J. Indian chem. Soc.*, 1947, **24**, 25).

Mezereon — *see* **Daphne**

MEZONEURON Desf. (*Leguminosae*)

Fl. Br. Ind., II, 257.

A small genus of climbing shrubs or rarely trees distributed in the tropics of the Old World. Four species occur in India.

M. cucullatum Wight & Arn. (TEL.—*Gabbusikaya*; TAM.—*Indu, matticcingai*; KAN.—*Mullodudballi*; MAL.—*Kakakalingivalli*; ASSAM—*Baghasora, baghanchora*; LUSHAI—*Lingkhang*; NEPAL—*Bakshikanra*; LEPCHA—*Neangkupzhu*) is a large, prickly climber with long bipinnate leaves found in the moist forests from Kumaon eastwards to Assam, Khasi and Lushai hills, Deccan, western ghats and Andaman Islands. It bears thin, reddish brown pods containing one compressed, reniform seed. The seeds are powdered and given to cows as a vermifuge (Cowan & Cowan, 53).

MICA

Micas represent a group of complex aluminosilicate minerals characterized by perfect cleavage in a single direction, due to which they can be split into extremely thin, flexible and tough sheets or laminae. Mica minerals crystallize in the monoclinic system, often in forms closely resembling pseudohexagonal or pseudo-orthorhombic systems, and exhibit, in many cases, twin structure. X-ray studies show a sheet like arrangement of low atomic structure and a hexagonal grouping of atoms.

The micas are extremely complex and variable in chemical composition. The principal members of the mica group are: Muscovite or potash mica [$H_2KAl_3(SiO_4)_3$]; Phlogopite or magnesium mica [$H_2KMg_3Al(SiO_4)_3$]; Biotite or magnesium iron mica [$H_2K(Mg,Fe)_3Al(SiO_4)_3$]; Paragonite or sodium mica [$H_2NaAl_3(SiO_4)_3$]; Lepidolite or lithia mica [chiefly, $(OH,F)_2KLiAl_2Si_3O_{10}$]; Zinnwaldite or lithium-iron mica [$Li_2K_2Fe_2Al_4Si_7O_{24}$]; and Lepidomelane or iron mica [$(H_2K)Fe_3(Al,Fe)(SiO_4)_3$]; within the general limits of the type formulae, substitutions of different elements may occur which alter the chemical composition without modifying the lattice structure

or affecting the physical properties. Minerals like Sericite (scaly muscovite), Roscoelite (vanadium mica) and Fuchsite (chrome bearing mica) also belong to this group.

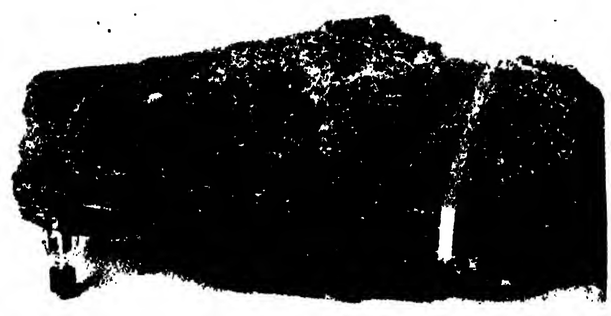
The common mica, muscovite, is the most valuable of all the micas. In thin films, it is colourless and transparent when pure; it may be stained and tinted due to impurities. In 'book' form, it is white, reddish or greenish in colour; Bihar muscovite is reddish in colour and is known in the trade as Ruby mica; muscovite from Andhra is greenish.

Phlogopite is known as Amber mica because its colour ranges from pale yellow to blackish brown. It is less transparent than muscovite; even in thin films it shows some tint or faint cloudiness.

Biotite is usually black in thick crystals, but thin laminae are brownish red or brownish green when viewed by transmitted light; it is often opaque in thin sheets. It does not split into thin films as readily as muscovite or phlogopite.

Lepidolite, zinnwaldite and roscoelite are used in industry mainly as sources of lithium and vanadium.

Muscovite and biotite in the form of small flakes are essential constituents of many igneous rocks, gneisses and schists: they also occur as secondary minerals in metamorphic rocks. Biotite disintegrates under the influence of weathering agencies and is not usually found in sedimentary rocks. The occurrence of muscovite in economic quantities is confined to coarse-grained pegmatite dykes of acid igneous origin consisting largely of quartz, felspar and mica. Phlogopite, on the other hand, is restricted to basic igneous rocks, especially pyroxenites, which are intruded into metamorphosed limestones and gneisses.



Geol. Surv. India. Photo: A. Latif

FIG. 132. BOOK OF MICA

TABLE 1—PRODUCTION OF MICA IN PRINCIPAL PRODUCING COUNTRIES*

(Qty in tonnes)

	1956	1957	1958
Blocks, Sheets & Splittings			
Angola	24	21	21
Australia	13	17	31
Argentina	140	96	n.a.
Brazil	1,328	1,482	1,419
India (exports)	9,250	7,532	6,470
Madagascar	539	964	922
Southern Rhodesia	56	32	48
Union of South Africa	1	1	1
Tanganyika	59	68	50
U.S.A.	131	313	200
Total	11,541	10,526	9,262
Waste Mica			
Angola†	439	383	325
Argentina	50	1	n.a.
India (exports)	12,338	12,844	10,887
Union of South Africa	2,287	1,919	1,931
U.S.A.	78,369	83,934	84,759
Total	93,483	99,081	97,902

* Indian Minerals Yearb., 1959, 245.
n.a. not available.
† Waste and splittings.

Workable mica deposits occur as veins or lenticular intrusions of pegmatites traversing mica schists or mica gneisses, and they usually carry a core of quartz surrounded by felspar or felspar-rich pegmatite. Books of mica occur commonly at the junction of the vein and the country rock, and also between the quartz core and felspar on its two sides (Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 221; Kirk & Othmer, IX, 69).

India is by far the largest producer of muscovite mica in the world, accounting for about 80% of the total world production of sheet mica and splittings. Brazil is the second largest producer. Muscovite mica is produced also in U.S.S.R., Argentina, Canada, Madagascar, Peru, Bolivia and a few other countries. Phlogopite is produced almost exclusively in Madagascar and Canada. Table 1 gives the production of mica in the principal producing countries during 1956-58.

Distribution in India

Muscovite occurs in commercial quantities in Bihar, Rajasthan and Andhra Pradesh. Phlogopite occurs in Kerala and Andhra Pradesh. Minor deposits have been reported from Mysore and Orissa.

The total reserves of mica in India have not been assessed as the occurrences are erratic. Of the three major mica belts situated in Bihar, Rajasthan and Andhra, the Bihar belt bears the richest veins, and yields muscovite ruby mica of excellent quality; Bihar and Andhra micas are generally of better quality than Rajasthan mica and fetch higher prices.

Andhra Pradesh—Most of the workable deposits of mica are found in Nellore dist. in a belt *c.* 60 miles long (NNW SSE) and 15–20 miles wide. The belt is V-shaped, tapering in the south at Vojili (south of Gudur); one arm passes northwards towards Nellore and the other north-west through Saidapuram and Udayagiri. The pegmatites are usually lenticular in shape and follow the strike of the enclosing schists; payable deposits vary from 100 ft. to several hundred feet in length and a few feet to 50 ft. in width; the mica yielding veins contain a preponderance of albite or microcline perthite; biotite, garnet, tourmaline, apatite and beryl are also common. Books of mica are usually 6–12 in. across and 2–6 in. thick; books measuring 2 3 ft. across and up to 12 in. thick are occasionally found. Mica mines are scattered throughout the belt, but are mostly located within the limits of Kavali, Atmakur, Rapur and Gudur taluqs around the following localities: Gudavalluru (15°0′:79°41′), Chinna Annaluru (14°53′:79°40′), Chinnakraka (14°51′:79°51′), Lakshmipuram (14°47′:79°48′), Dundigam (14°42′:79°48′), Srikolanu (14°40′:79°47′), Vasili (14°37′:79°40′), Suryapalem (14°34′:79°44′), Thimmayapalem (14°31′:79°35′), Battulapalli (14°31′:79°42′), Nallapalem (14°30′:79°45′), Tatiparti (14°31′:79°47′), Prabhagiripatnam (14°27′:79°45′), Toderu (14°24′:79°46′), Marupuru (14°24′:79°48′), Inukurti (14°20′:79°43′), Degapudi (14°19′:79°43′), Vadlapudi (14°18′:79°48′), Devaravemur (14°17′:79°46′), Tummalatalupur or Talupur (14°18′:79°41′), Kalichedu (14°18′:79°44′), Turimerla (14°16′:79°44′), Griddalur (14°16′:79°47′), Utukur (14°14′:79°44′), Jogipalli (14°13′:79°44′), Chaganam (14°12′:79°41′), Saidapuram (14°10′:79°44′), Turpupundla (14°12′:79°47′), Ananthamadugu (14°8′:79°43′), Chennur (14°9′:79°47′), Mangalapur (14°7′:70°47′), Tippanuru (14°5′:79°51′), Mekamuru (14°4′:79°50′), Voduru (14°4′:79°52′), Rettapalli (14°5′:79°53′) and Patharegunta (14°3′:79°54′). Many of the pegmatites are now being worked at depths of 300–500 ft. from the surface (Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 227–29; Roy, *Bull. geol. Surv. India, Ser. A*, No. 11, 1956, 12, 15).

Nellore mica is light green in colour; it is generally stained and spotted. A variety with a shade between green and ruby, locally known as honey mica, is found around Nallapalem, Tatiparti, Prabhagiripatnam and a few other places. The mines of Mudigodu, Kalichedu and Utukur yield a pale ruby variety which compares favourably with Bihar mica. A few isolated ruby veins are seen in the vicinity of Tellabodu (Chaganam area) and Shah mines (Saidapuram area).

In Visakhapatnam dist., phlogopite occurs near Kudia (18°7′:82°4′) and Majigudem (18°12′:82°54′). Specimens measuring up to 18 in. or more across are sometimes met with; they are usually buckled and cracked. Phlogopite also occurs in small deposits near Masigudem (18°12′:82°53′), Mandragudem (18°10′:82°54′) and Borra (18°17′:83°3′): the occurrence near Borra covers an area of 1 sq. mile and books of mica measuring up to 18 in. across are not uncommon. White and greenish muscovite of good quality has been reported from Kurupam estate. Near Waltair, on the Visakhapatnam-Pendurti road, light ruby mica has been found on a hillock (17°44′:83°16′30″) (Krishnan, loc. cit.; Dey, *Indian Miner.*, 1950, **4**, 182).

In West Godavari dist., minor mica occurrences have been reported from Ankanagudem (17°18′:81°14′) and Kovvurupadu (17°11′:81°32′). The deposits in the latter area were being exploited between 1917 and 1924; efforts are being made to reopen the quarries. Muscovite also occurs at Dhanimetta, south of Nandigudem (17°9′30″:81°30′), and near Pochavaram (17°9′:81°39′), Gangolu (17°12′:81°34′) and Karcharlagudem (17°7′30″:81°30′) [Krishnan, loc. cit.; Krishnaswamy, *Rec. geol. Surv. India*, 1954, **85**(1), 78].

In Krishna dist., several workable mica deposits occur in Tiruvur taluk. Spotted and slightly brownish mica, measuring up to 6 in. across, has been found at Tiruvur (17°7′:80°37′), Gosavidu (16°56′:80°29′), Kanmuru (17°0′:80°34′), Vavilala (17°05′:80°32′), Lakshmipuram (17°05′:80°38′) and Konduru (16°58′:80°39′). A deposit *c.* 3 furlongs west of Tiruvur yields ruby mica of good quality. Light green muscovite has been worked in a valley near Jammalavoidurgam peak. Mica-bearing pegmatites also occur west and

south-west of Tiruvur, near Kammarkuntla (16°51′: 80°40′), Gollamandla (16°59′:80°40′30″), Gampalagudem (17°0′:80°31′30″) and Ramachandrapalem (16°52′30″:80°38′30″) [*Indian Miner.*, 1948, **2,** 185: Ziauddin, *Rec. geol. Surv. India*, 1954, **86**(1), 118; Krishnan, loc. cit.].

In Guntur dist., mica has been noted in surface pegmatites on the Kondavidu hill range, particularly on the flanks of Mangala Konda, east of Perecherla railway station. Smaller occurrences have been reported in various areas of the former Hyderabad state. Mica occurs at Muchavaram, Battalpali and Kappalbandam all in Madhira taluk (Khammam dist.) and in a few other localities in Nizamabad and Adilabad districts [Rao, *Quart. J. geol. Soc. India*, 1950, **22,** 74; Mirza, *Bull. Hyderabad geol. Ser.*, No. 5, 1943; *Rec. geol. Surv. India*, 1954, **86**(1), 118].

Bihar Most of the world's supply of high quality block mica is obtained from the Bihar mica belt, an area extending from Gaya dist. on the west for 90 miles through Hazaribagh and Monghyr districts to Bhagalpur dist. on the east: the width of the belt ranges from 16 to 20 miles. The mica content of the pegmatites in the belt varies from 2 to 36%. The main centres of production are Kodarma, Domchanch, Gawan, Tisri, Chakai and Charkapathal. Books of mica found within the belt vary widely in size: the larger among these are *c.* 3 ft. across to 2 ft. or more in thickness; the average size is 6-12 in. across × 3-4 in. thick; the smallest marketable size is about one inch square [Jacob & Mahadevan, *Indian Min. J.*, 1957, **5**(10), 54].

The principal mining centres in Gaya dist. are: Singar (24°34′:85° [illegible] Dabur (24 [illegible] Rajauli (24°39′:85°30′).

The more important mica-bearing localities in Hazaribagh dist. are: Kodarma Reserve Forest north of Kodarma (24°28′:85°36′), Chatkari, Dhorhakola, Domchanch (24°28′:85°42′), Dhengura (23°57′:85°20′), Dhab (24°35′:85°46′), Gawan (24°37′: 85°55′), Masnodih, Parsabad (24°19′:85°45′), Tisri (24°35′:86°4′), Bendi (24°30′:85°25′), Charki (24°34′: 85°50′) and Garia (24°23′30″:85°03′). At Dhengura, located 5 miles from Hazaribagh town, is a small mica-bearing area outside the so-called mica belt.

The largest production from the belt, in the past, was from an area of *c.* 57 sq. miles within the Kodarma Reserve Forest region. In recent years, large quantities are obtained from other areas, in the north-east and east of the Reserve Forest (Khedker, 175).

In Monghyr dist., mica occurs at Mahesri (24°41′: 86°15′), Nawadih or Jhajha (24°47′:86°23′), Chakai and a few other places.

Outside the mica belt, the mineral has been obtained from Singhbhum and Palamau districts. In Singhbhum dist., pale green mica is found at Puranadihi (22°20′:86°39′), Benagaria (22°19′:86°38′) and Lanbera (22°32′:85°41′).

In Manbhum dist., the mineral has been worked at Chitra (23°32′:86°26′), Kanki (23°35′:86°29′), Sonkupi (23°08′:86°04′), Kodori (23°22′:86°50′) and Malancha (23°25′:86°44′). Mica also occurs in Ghatbera (23°11′:86°13′), Marlong (23°27′:86°01′), Taherbera (23°28′:86°02′), Jabar (23°27′:86°01′), Maramo (23°28′:86°02′), Simni (23°27′:86°00′), Bhursa (23°09′:86°40′), Rangadih (23°01′:85°53′), Churku (22°49′:86°36′), Jhairbaid (22°48′:86°36′), Jashpur (22°48′:86°36′) and between Urma (23°43′:86°42′) and Chirudih (23°43′:86°37′). Books of ruby to light green muscovite, often ribbed and stained, have been noted near the following places: Chuna (23°25′: 86°36′), Parasibona (23°25′:86°34′), Pinra (23°24′: 86°36′) and Rudra (23°25′:86°38′) [Dunn, *Mem. geol. Surv. India*, 1954, **86**(1), 120; 1958, **87**(1), 131].

In Palamau dist., mica occurs near Daltonganj (24°02′:84°04′), Lesliganj (24°02′:84°12′), Kini (24°04′:84°01′) and Khorhi (24°02′:84°00′). Mica has also been recorded from Sikriadnur (22°41′:84°29′) and near Lohardanga in Ranchi dist.

The strike and dip of the larger mica veins occurring within the mica belt are usually parallel to the cleavage of enclosing schists, but there are many veins which cut across the cleavage. The majority of payable veins are less than 100 ft. in length, though strikes up to 1,000 ft. have been reported.

Hazaribagh dist. accounts for about 76% of the State's production, the contributions of Gaya and Monghyr districts are 19% and 4% respectively. Bihar mica is usually of ruby colour; green, white, silvery and brown micas are also found but only in limited quantities. White mica is mined to a small extent from the Singar mine (Gaya dist.) [Ghosh, *Indian Min. J.*, 1953, **1**(9), 19].

Gujarat In Sabarkantha dist., mica of inferior grade occurs at Bodi (23°33′:73°13′), Limbhoi (23°53′:73°0′) and Dobhara (23°59′:72°59′) (Roy, 1951, 141).

Kashmir—Mica has been located in pegmatite veins at Padar in Uri tehsil and in Kishtwar, Karnah

and Ladakh areas. The deposits are of no economic importance (Badyal, *East. Met. Rev.*, 1955–56, **8**, 630; Malhotra, ibid., 1957–58, **10**, 908).

Kerala—Phlogopite of good quality occurs near Tiruvankod (8°14′:77°18′), over an area, *c.* 2 sq. miles in extent. From a quarry near Vettiyurkavu, *c.* 5 miles from Trivandrum, phlogopite sheets up to 10 in. across have been obtained, the average size being 2–5 in. Phlogopite also occurs south of Punalur railway station (9°1′:76°56′). In Cannanore dist., ruby mica of good quality was extracted during World War II from pits at Chovva, 1½ miles east of Cannanore railway station (Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 239, 236).

Madhya Pradesh—Mica occurrences have been reported at Chitaldongri (22°8′:80°31′) and Bamui (22°8′:80°41′) in Balaghat dist. In Bastar dist., muscovite occurs south of Jungani (19°45′:81°43′): the mica is of little economic value as it is weathered and damaged by gliding planes. Mica is found in Komochoki (22°36′:82°07′) and in the pegmatites of Narsinghpur and Chhindwara, in Bilaspur dist. White and unspotted muscovite is found in a stream bed at Tilairwar (21°2′:80°47′) in Nandgaon area. In Rewa dist., mica occurs at Bardghata (23°58′:82°47′) and Mainadhyi (23°58′:82°38′) near Pipra. Mica of inferior quality is found in the former Surguja state, near Haldibaria, Sulsuli, Paharkarwan, Semra and Nawgain.

Madras—In Tiruchirapally dist., muscovite mica (size, 2–5 in. across) is found near Aiyampalaiyam (10°34′:78°10′), Anaikuttitottam, Kadavur (10°35′40″:78°11′30″) and on the north-east spur of Mungilmalai. Old workings of mica have been noticed in these localities.

Workable deposits of mica occur in a few places in Tiruchengodu and Omalur taluqs (Salem dist.). Muscovite has been mined intermittently in the past from a pegmatite (*c.* 300 ft. long × 60 ft. wide) half a mile east of Kurumbapatti (11°35′:77°52′). Mica obtained from this locality is light ruby in colour and up to 6 in. across. Mica workings are found near Karaiyannur (11°30′:77°56′), Pallippatti (11°33′:77°55′), Dasavilakku (11°38′:77°58′) and Alachchiampalaiyam (11°35′:77°49′) (Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 235; Aiyengar, *Indian Miner.*, 1949, **3**, 77).

In Coimbatore dist., mica occurs near Karatapalaiyam (11°3′:77°35′), Padiyur (11°3′:77°33′), Vairamangalam (11°27′:77°37′), Errappanayakkanpalaiyam (11°31′:77°31′) and Punjai Puliyampatti (11°21′:77°10′). A few old workings exist in some of these areas.

In the Nilgiri region, several good deposits of mica occur in the forested areas of Wynaad, near Gudalur (11°30′:76°29′), Nellakota (11°34′:76°27′), Chunduvayal (11°31′:76°26′), Devala (11°28′:76°26′), Puliamparai (11°29′45″:76°26′), Tambattimalai (11°32′:76°20′), Kolappalli (11°32′:76°20′), Ammankaval (11°21′:76°21′) and Cherambadi (11°32′:76°22′). Mines near Tambattimalai and Cherambadi yield ruby muscovite of fairly large size. Workable deposits have been reported from the neighbourhood of Musnigudi (11°34′:76°38′).

Occurrences of muscovite have been reported from several other areas, e.g. Uchimalaikuppam (Chengam taluq) in North Arcot dist., Batlagundu (10°10′:77°46′) in Madurai dist. and Kila Singampatti (8°40′:77°26′) in Tirunelveli dist. Pegmatite veins in Singampatti hills carry light amber mica having a composition intermediate between muscovite and phlogopite.

Maharashtra—Sizeable mica deposits have been reported from Kadaval (16°8′:73°49′) in Ratnagiri dist.; they are reported to be large enough to yield annually 190 tons of mica for 10 years.

Mysore—In Hassan dist., mica is found in the Kabbur block, and east of Chikkanhalli (12°46′:76°10′). In Kadur dist., mica has been mined near Kirki (13°25′:75°20′). In Mysore dist., workable deposits occur at Undivadi (12°24′:76°37′) and near Vadesamudra (12°33′:76°47′), north-east of French rocks; fairly large books free from flaws are found in the Krishnarajasagara area. Mica occurs also at Hebbal (15°27′:76°37′), Naolihatti, Devanpalli (16°9′:77°25′) and a few other places in Raichur dist., and at Nagnur in Gulbarga dist.

In South Kanara dist., occurrences of buckled muscovite has been reported from Ulamagaru (12°42′:75°15′), Madnur (12°38′:75°16′), Sullia (12°35′:75°25′), Arantod (12°32′:75°27′), Sampaje (12°30′:75°33′), Kalanjia (12°39′:75°24′), Kuthkunja (12°39′:75°29′), Kombar (12°46′:75°34′) and Bilinile (12°43′:75°33′). Detailed prospecting work has not been undertaken in these areas (Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 236).

Orissa—In Mayurbhanj dist., books of mica measuring more than 8 sq. inches in area, have been obtained from pegmatite veins exposed along the Sankrai river near Jamgodia (22°6′:86°34′). Mica of smaller size occurs near Sirsa (22°14′:86°42′), Bangarposi (22°09′:86°35′), Tiringdih (22°31′:86°8′) and Raibedi (22°27′30″:86°4′).

In Sundargarh dist., muscovite mica occurs in pegmatite veins near Ghoriajor, Tangarmunda (between Bamra and Garpos) and Potatangar: the material is not of marketable quality (Krishnan, *Mem. geol. Surv. India*, 1937, **71,** 179).

In the former Jashpur state, muscovite occurs in pegmatite veins near Kainkachhar ($22°48':84°10'$), Jampani ($22°48':84°13'$), Jurwani ($22°48':84°15'$), Thuti Amba ($22°48':84°16'$), Rengola ($22°48':84°7'$), Jagmara ($22°47':84°8'$), Dameraghat ($22°47':86°6'$), Keondpani ($22°45':84°12'$), Teratoli ($22°44':84°14'$), Bartoli ($22°42':84°9'$), Jhargaon ($22°42':84°12'$) and east of Barnijortoli ($22°43':84°13'$) [Dey, *Rec. geol. Surv. India*, 1949, **78**(1), 35; 1937, **72**(1), 53].

In Cuttack, Sambalpur, Ganjam and Koraput districts, mica has been mined intermittently in some areas. The deposits at Borriguma ($19°03':82°33'$) in Koraput dist. are of some importance (Economic Geology of Orissa, 98–105; Dey, *Rec. geol. Surv. India*, 1954, **80,** 525).

In the former Dhenkanal state, deposits of mica occur near Soratnali ($20°49':85°26'$), Bhernia ($20°50':85°25'$), Chandpur ($20°49':85°26'$) and Toradanali ($21°06':85°24'$), the deposits were worked during World War II. In the former Bamra state, mica-bearing pegmatites have been seen at Saplat ($21°30':84°8'$), Mundhianpali ($21°29':84°9'$) and Sahajbahal ($21°28':81°11'$); the material mined at Saplat is of good quality. A mica belt roughly 18 miles long by 3 miles broad, extends from the Dhenkanal-Talcher boundary of the former Talcher state and runs westwards along the foot of the Baruan range through Gaham and Durgapur to Chintamanipur and finally reaches Tikra on the north-east of Ghantianali near the boundary of Talcher and Angul. The pegmatites at Bulajhar, Durgapur and Chintamanipur are expected to yield mica of good quality. Deposits of mica of inferior quality have been reported from Athmalik, Rairakhol, Athgarh, Hindol, Tigiria, Pal Lahara and few other states which formed the former Eastern States Agency [Dey, *Rec. geol. Surv. India* 1954, **80,** 525; Muktinath, ibid., 1954, **79**(2), 438; Crookshank, *Indian Miner.*, 1947, **1,** 169].

Punjab—Mica has been reported to occur at Mahanti and Bhunsi ($28°21':77°7'$) in Gurgaon dist. In Kangra dist., books of brown mica, 5–6 in. across and 1–2 in. in thickness, occur in granite at Wangtu Bridge ($31°32':78°4'$) on the Sutlej river. In Kulu, mica plates of marketable size have been obtained in Chandra valley near Hamta Pass ($32°16':77°26'$) and in Parbati valley.

In Mohindergarh dist., books of mica, up to 9 in. × 6 in., have been obtained from Gatasher ($27°58':76°6'$), Saraili, Musmuta and Panchnauta ($27°53'30'':76°4'$).

Rajasthan—Rajasthan is the second largest mica producing State in India, next only to Bihar. The mica-bearing pegmatites follow generally N.NE-S.SW strike, over a distance of *c.* 200 miles, stretching from Jaipur in the north-east to Udaipur (Mewar) in the south-west. In the central region, the mica-bearing zone broadens around Kumbhalgarh and Bhilwara and extends further north-east to Ajmer, Kishangarh and Jaipur.

The mineral occurs in coarse granitic pegmatites, differentiated into quartz cores and felspathic mica-bearing margins, as in the Bihar mica field. The accessory minerals include tourmaline, apatite, garnet and rarely radio-active and rare-earth minerals and beryl. The pegmatites intrude into the surrounding rocks of the gneissic complex and into the Aravalli schists: the intrusives vary from a few feet in length and a few inches in width to whole ridges extending up to 500 yd. in length and 100 yd. in width. The region is relatively flat, but pegmatite outcrops are often found above the level of the surrounding country. The mineral occurs sporadically in rich shoots, normally not more than 4 ft. thick, and much of the mica is black-spotted; about 40% of the total mica is of the ruby variety. A good part of the material from shallow workings is often stained, warped and cracked, but that won from depths is expected to be of good quality (Coggin Brown & Dey, 543).

Mica mines in Bhilwara dist. are located in or near the following places: Nath-ki-Neri ($25°23':74°17'$), Tunka ($25°18':74°24'$), Sedrias ($25°25':74°47'$), Bagor ($25°21':74°23'$), Chapri ($25°21':74°20'$), Sareri ($25°38':74°26'$), Gundli ($25°20':74°28'$), Banjari ($25°22':74°22'$), Ghoras ($25°23':74°28'$), Bemali ($25°79':74°9'$), Jamoli near Jahazpur ($25°35':75°11'$), Kocharia ($25°19':74°30'$), Gokulpura ($25°29':74°33'$), Amargarh ($25°21':74°29'$), Asaoli ($25°20':74°19'$) and near Mahendragarh fort ($25°16':74°24'$). The mine near Tunka produces over 2 tons of mica per day and is worked by underground methods. Next in importance is the Gundli mine with an output of *c.* 1.5 tons of mica per day; production in other mines varies from 0.22 to 0.55 tons per day (Sethi, 138; Roy, *Mem. geol. Surv. India*, 1959, **86,** 251).

In Udaipur dist., ruby mica is obtained at Champa Gudha, 3 miles north of Charbhuja Road railway

station, Dholamatura (25° 14′ : 74° 01′), Gulwa (25° 11′ : 73° 03′) and Miari (25° 11′ : 73° 50′). Other important mines in the district are Sambhupura (23° 11′ : 74° 5′), Tarakhera (23° 7′ : 74° 9′), Bagpura (23° 10′ : 74° 5′), Kabri (23° 10′ : 75° 5′), Jharol (23° 15′ : 74° 7′) and Khemala (23° 19′ : 74° 10′). Mining in several areas has been suspended at present due to influx of water and lack of adequate machinery.

In Jaipur dist., copper-stained black mica is obtained from a mine situated near Banjari (26° 27′ : 74° 58′) in Arain tehsil; another mine situated near Dadia (26° 25′ : 74° 58′) yields ruby mica which is stained. Other important mines in the district are: Bhojpura (26° 28′ : 75° 30′), Madhorajpura (26° 53′ : 75° 38′) and Karanwa-ka-Bas (26° 28′ : 75° 30′) in Phagi tehsil. Mica pegmatites occur in areas around Arur (25° 49′ : 74° 49′), Badla (25° 46′ : 75° 01′), Barla (25° 49′ : 74° 51′), Borara (26° 12′ : 75° 03′), Fatehgarh (26° 08′ : 75° 02′), Imantia (25° 47′ : 74° 46′), Khamor (25° 45′ : 74° 47′), Khirian (26° 06′ : 74° 54′), Kohara (26° 07′ : 75° 15′), Natrias (25° 47′ : 74° 50′), Phulia (25° 49′ : 74° 58′), Sangria (25° 51′ : 74° 52′) and Tajpura (26° 0′ : 75° 03′) in Jaipur and Udaipur divisions. The pegmatites are traceable for over 100 ft. along the strike and show distinct quartz and felspar zones. The majority of them show a N.NE-S.SW trend. The mica is black-spotted, copper-stained or ruby-coloured. The pegmatite vein at Badla is exposed for a length of *c.* 200 ft. in a roughly NE-SW direction and is being exploited at depths below 80 ft.; the output per day is *c.* 0.25 tons [Sethi, 144; Kurien, *Rec. geol. Surv. India*, 1958, **88**(1), 133].

In Tonk dist., mica-bearing pegmatites are found at Barla (25° 52′ : 75° 17′), Mankhand (26° 00′ : 75° 16′), Sankarwara (25° 57′ : 75° 27′), Barchola (2 miles south-west of Sankarwara), Miron (26° 12′ : 75° 33′), Dholi (3 miles east of Diggi railway station), Baroni (26° 17′ : 75° 54′) and Palri (3 miles south-east of Tonk city). Several mines were operating in this district up to the end of World War II, but due to a slump in the market many of them are now out of production (Sethi, 142).

In Sikar dist., stained or green mica is obtained from mines located at Kachrada (27° 45′ : 75° 59′), Makri (27° 47′ : 75° 49′) and Maonda (27° 48′ : 75° 50′) in Torawati tehsil. In Sirohi dist., mica of good quality and fair size occur near Rohira (24° 37′ : 73° 01′ 30″) and Sabela (24° 47′ : 73° 08′) (Roy, *Mem. geol. Surv. India*, 1959, **86**, 245).

In Ajmer-Merwara, mica occurs near Shokla (26° 13′ : 74° 54′), Champaneri (25° 58′ : 74° 54′), Baori (26° 12′ : 74° 59′), Tihari (26° 24′ : 74° 58′), Gadi (26° 05′ 74° 24′), Dudpura (26° 06′ : 74° 23′), Bisundni (25° 44′ 75° 12′), Kekri (25° 57′ : 75° 10′), Lohagal (26° 30′ 74° 39′) and Chorasiawas (26° 30′ : 74° 37′). Mica is being mined at Shokla, Champaneri, Gadi and several other places. The material obtained from Lohagal area is of good quality [*Rec. geol. Surv. India*, 1954, **85**(1), 78; Roy, *Mem. geol. Surv. India*, 1959, **86**, 239].

Uttar Pradesh—In Mirzapur dist., books of ruby mica up to 4 in. × 4 in. size occur in Dhurpa (24° 9′ : 83° 20′) area [Murthy, *Rec. geol. Surv. India*, 1953, **84**(1), 104; Mehta, ibid., 1953, **79**(1), 326].

West Bengal—Mica-bearing pegmatites occur at Shairbinda (22° 45′ : 86° 40′), Chakadoba (22° 46′ : 86° 39′) and Dhenkia (22° 47′ : 86° 37′) in Midnapur dist. In Bankura dist., mica has been located at Bankata (23° 03′ : 86° 44′), Kharbani (23° 09′ : 86° 44′), Bansidihi (23° 07′ : 86° 53′), Kalpathar (23° 04′ : 86° 52′), Tisra (23° 14′ : 87° 0′) and a number of other places. The material obtainable from these areas is generally stained and of small size [Dunn, *Mem. geol. Surv. India*, 1937, **69**(1), 138; Hunday, *Rec. geol. Surv. India*, 1954, **85**(1), 77; 1954, **86**(1), 120].

Mining and Dressing

Mica deposits are worked either by open-cast surface working (*uparchalla* working) or by underground mining. The quarries in open-cast working extend to a depth of *c.* 20 ft.; as the workings extend deeper, mining is carried out by underground methods using machinery for drilling and hoisting and for pumping water. In former times, underground working was seldom planned and mica was extracted wherever it was found. Improved methods are now followed and payable mica-bearing veins are now being systematically opened up, developed and blocked to their limits along the strike and dip by vertical shafts, drives and winzes. The mineral reserves in different blocks are removed by overhead stoping until the mine is completely worked out (Dunn, *Rec. geol. Surv. India*, 1942, **76**, *Bull. Econ. Miner.*, No. 10, 40).

Much care is taken in drilling and blasting in order to avoid the damaging of books. In the larger mines, development work is done by machine drilling; hand drilling is adopted in stoping. The vein material is brought down with crow bars and crude mica books sent to cutting sheds for dressing.

FIG. 83. INTERIOR OF A MICA MINE, ANDHRA PRADESH

During 1959, 630 mines were reported to be in production; of these about 450 were in Hazaribagh (Bihar) dist. alone. The bulk (c. 75%) of mica output from Bihar is obtained from underground mines using mechanical appliances. The average depth reached in mines is c. 250 ft. while in some, mica is now extracted at depths of 700 ft. The majority of mines in the Nellore mica belt and Rajasthan are worked by open-cast method; the workings are limited in depth (Indian Minerals Yearb., 1959, 234).

Dressing—Mica as obtained from mines is usually mixed with pegmatite material. Preliminary dressing (cobbing) of crude mica is done at mine sites and in trimming shops. The blocks are freed from dirt and waste as well as from defective material, such as ruled, buckled, wrinkled and wavy mica, and only sound mica is retained. Cobbed mica is then rifted or split up into sheets of 1/8, 1/16 or 1/32 in. thickness or less. Rifted sheets are trimmed by breaking off defective material around edges. Trimmed mica, also known as sheet mica, is further split into thinner sheets (splittings) with sickles, shears or knives.

In Bihar, most of the dressing and splitting is done in centres in and around Kodarma, Giridih and Hazaribagh. *Uparchalla* quarry owners from other districts of Bihar, send their crude mica blocks to these centres for dressing; roughly trimmed blocks from Rajasthan are also sent to these centres. Trimming is done by sickles: the shape of sickle-trimmed or Indian trimmed mica is irregular with bevelled edges. In Andhra Pradesh, mica is cut by means of shears: shear-trimmed mica is roughly circular in shape with cut edges perpendicular to the cleavage plane. Trimmed blocks are sorted according to quality and size. During the sorting, blocks may be further trimmed by knife to eliminate stained and flawed material and then split into sheets: split sheets may be dressed further to improve the

FIG. 134. CUTTING MICA SHEETS

quality. The amount of wastage in final trimming varies from 3 to 4%.

Various mechanical devices have been patented for splitting mica. These devices are hardly used in practice and splitting is almost entirely effected by hand with the help of thin, sharp-pointed knives or shears.

Properties and Uses

Micas are distinguished by their having a highly perfect cleavage, due to which they can be split into thin sheets and films. Different kinds of mica vary in colour from colourless and transparent, through various shades of yellow, green, red and brown, to black and opaque. The specific gravity of micas varies from 2.7 to 3.1 in different types. The hardness of muscovite and the softer phlogopite varies from 2.0 to 2.5 and that of harder phlogopite and biotite, from 2.5 to 3.0. Phlogopite is somewhat more flexible than muscovite, but is not so elastic as the latter.

In their optical characteristics, the micas exhibit considerable variation. The mean index of refraction is 1.58–1.60; but the double refraction is very strong and negative in sign. The angle between the optic axes varies from 70–50° in muscovite to 10 0° in biotite and phlogopite. The plane of the optic axes may be either perpendicular or parallel to the plane of symmetry to the crystal; it is perpendicular in the case of muscovite and parallel in the case of phlogopite.

Micas are bad conductors of heat and electricity and many technical applications of mica are based on these properties. The dielectric strength varies from 3.3 to 8.5 Kv./mil. in muscovite and from 4.3 to 5.9 Kv./mil. in phlogopite. Mica has a very high dielectric constant (K, 6.5–8.5) and extremely low power factor or power loss (0.02–0.04%).

The water which is present in muscovite to the extent of 4–6% and somewhat less in other types, is expelled only at high temperatures. Muscovite starts to lose its water of crystallization at about 550° while phlogopite begins to lose water only above 850°.

Under ordinary conditions, micas are unaffected by fire, water, acids or alkalies. The chemical composition of muscovite from Bihar and Andhra is given in Table 2.

Uses—More than 90% of the world production of sheet mica is consumed by the electrical industry. Block and film mica are used in the manufacture of commutators, armatures of dynamos, radio tubes, television transmitters, transformers, spark plugs, condensers, etc. Block mica, mica splittings and built-up mica are used in ignition coils of motor cars and as insulators in domestic electrical appliances. Mica is also used as washers and discs for electrical and thermal insulation in mechanical and electrical appliances.

FIG. 135. SPLITTING MICA SHEETS

TABLE 2—ANALYSES (%) OF MUSCOVITE FROM BIHAR AND ANDHRA*

	Bihar	Andhra (Nellore)
SiO_2	45.57	46.42
Al_2O_3	36.72	36.77
Fe_2O_3	0.95	0.21
FeO	1.28	1.64
MgO	0.38	0.72
CaO	0.21	1.28
K_2O	8.81	8.94
Na_2O	0.62	0.72
Li_2O	0.19	..
H_2O	5.05	3.24
F	0.19	Tr.
Total	99.97	99.94

* Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 221.
Tr.=Traces.

Phlogopite is preferred to muscovite for use in heating elements, electric soldering irons, military searchlights and aircraft spark plugs. It is generally specified for the insulation of commutator segments because it wears as fast as copper and thus keeps the commutator surface smooth. Phlogopite cannot be used as condenser films on account of its high power factor (Dey, *Rec. geol. Surv. India*, 1954, **80**, 494; Kirk & Othmer, IX, 72).

Mica splittings are used in the manufacture of micanite or built-up mica board in which splittings, 1–3 sq. inches in area are cemented with shellac or other insulating cement. Micanite can be formed to any desired thickness and it can be cut into any desired shape. It is extensively used for electrical insulation. The consumption of mica splittings in the form of built-up mica is larger than the aggregate consumption of all other unmanufactured mica, except scrap mica. Powdered mica is employed in the preparation of glass bonded mica, or Mycalex, for use as insulation in electrical equipment.

On account of its transparency and resistance to fire and sudden changes of temperature and to breakage, mica has been much employed for windows of stoves and lanterns, peep-holes of furnaces, and chimneys of lamps and gas-burners. Sheets of mica are used as a surface for painting, as a protection covering for pictures and documents, for vanes of anemometers and mirrors of delicate physical instruments, and for various optical and other purposes. Being a bad conductor of heat, it is used for the packing and jacketing of boilers and steam pipes.

Finely ground mica is used in the roofing trade as a backing for rolled asphalt and shingles. Powdered mica is also used as foundry facing, in the manufacture of paints and wall paper, as a lubricant and as a filler in plastics and rubber formulations. Ground mica is used also in oil well drilling (Coggin Brown & Dey, 539).

Mica is processed into micanite and other products by the *Indian Mica and Micanite Industries Ltd.*, Jhumri-Telaiya (Bihar); the *Micanite & Mica Products Co. Ltd.*, Gudur (Andhra); and the *Bhupal Mining Works*, Bhilwara (Rajasthan). The Jhumri-Telaiya plant produces *c.* 51 tonnes of micanite per year; its production capacity is, however, much higher (305 tonnes/yr.). The other factories are not producing micanite at present. The factory at Gudur produces condenser films of different types and dry ground mica of various meshes: the ground mica is consumed principally by M/s *Dunlop Rubber Company*. The Bhilwara factory produces mica insulating refractory bricks from ground mica: the production capacity of this factory is 60,000 bricks (*c.* 60 tons) per month: the present output is, however, only 20,000 bricks per month (Indian Minerals Yearb., 1959, 236).

Quality, Grading and Classification

For use in the electrical industry, mica should be free from flaws and cracks and should be in as large pieces as possible. Books of mica should be perfectly flat and easily splittable. The sheets should be free from waviness, caused by distortion of crystals, and cross-grains or *jatahi* (tangled laminations): waviness and cross-graining cause imperfect cleavage which results in tears or breaks during splitting. The value of mica is appreciably reduced by stains due to the intrusion of clay, earth or mud between the laminae or by the presence of iron, air bubbles and pinholes or pinpits caused by the penetration of minute crystals of garnet, quartz or beryl. These defects affect the electrical insulating properties of the mica sheets. Pinholes and some type of stains etc. are removed during dressing.

Dressed mica is sold as Blocks (*tikri*), Thins, Splittings (*phakri*) and Condenser Films. The minimum thickness specified for Block mica is either 0.20 mm. or 0.18 mm. as agreed to between the buyer and the seller; a maximum tolerance of 5% (by wt.) of thinner blocks is permitted. Knife-dressed

TABLE 3—MICA GRADES ACCORDING TO SIZES *

Bihar Grade	Area (sq. in.)	Nellore Size No.	Area (sq. in.)
Over Over Extra Extra (OOEE) Special	100 and over	IX	96–112
Over Extra Extra (OEE) Special	80–100	VIII	80–96
Extra Extra (EE) Special	60–80	VII	64–80
Extra (E) Special	48–60	VI	48–64
Special	36–48	V	32–48
1	24–36	IV	16–32
2	15–24	III	8–16
3	10–15	II	4–8
4	6–10	I	<4
5	3–6		
5½	2.5–3		
6	1–2.5		
	0.75–1		

* Banerjee, *Indian Miner.*, 1956, **10**, 12; Roy, *Bull. geol. Surv. India, Ser. A*, No. 11, 1956, 33.

mica, which is thinner than block mica is designated as Thins (thickness, 0.05–0.18 mm.). Laminae split from blocks and thins are called Splittings: the thickness of 10 laminae taken together should not exceed 0.28 mm. Very thin laminae used in capacitors or condensers are designated as Condenser Films (IS : 1174–1957).

Block mica and thins are size-graded on the basis of maximum usable rectangular area and further classified on the basis of quality for shipment abroad. Blocks of small size and of poor quality are converted into splittings.

Based on quality, mica is classified according to clearness, hardness, flatness, colour, air inclusions, stains, etc. Size-grading for processed mica is based on the maximum usable rectangular area that may be cut from each piece and not on the total area of the piece. The standard grades of Bihar and Nellore mica are given in Table 3. Table 4 gives the classification of Bihar mica according to quality. Indian Standards for the grading and classification of muscovite mica based on size are given in Table 5.

Though the grading of block mica according to size is more or less standardized in producing centres, the procedures for classifying mica according to quality vary somewhat not only between centres but also between individual producing firms.

A coordinated system for the classification of muscovite mica according to visual quality has been developed. The system recognizes 16 categories, namely, Ruby Clear, Ruby Clear and Slightly Stained, Ruby Fair Stained, Ruby Good Stained, Ruby Stained A Quality, Ruby AQ, Ruby Stained B Quality, Ruby BQ, Ruby Heavy Stained, Ruby Densely Stained, Black Dotted, Black Spotted, Black Stained, Green/Brown First Quality, Green/Brown

TABLE 4—CLASSIFICATION OF BIHAR MICA ACCORDING TO QUALITY *

Quality	Characteristics
Superfine	Hard and optically flat; must contain no stain or flaw of any description
Clear & slightly stained	Hard, substantially flat and free from cracks; largest rectangle obtainable must be free from mineral inclusions and stains, but may contain small air stains within a small part of the rectangle
Fair stained	Hard and free from cracks, but may be slightly wavy; largest rectangle obtainable may contain some small air stains and, within a small part of the area, may contain small light stains
Good stained	Hard and free from cracks; may be wavy but not buckled; may contain air stains throughout, and light stains & heavier stains over a small part of area
Stained	Fairly hard; may be wavy and slightly, but not badly, buckled; should be free from cracks; may contain stains and small mineral inclusions on edges and heavier stains over a small part of the area
Heavily stained	May be slightly buckled; may contain heavy stains and mineral inclusions over a part of the area
Densely stained	May be partly buck'ed; may contain dense stains and scattered mineral inclusions
Silver stained & white	As for stained, but air stains may be of such a pervading character as to impart a silvery or white appearance to whole surface
Dotted	As for good stained, but with isolated black dots throughout
Densely stained & spotted	As for densely stained, but with heavy spots and mineral inclusions
Black spotted	Hard and flat, with spots and streaks and mineral inclusions throughout; spots and streaks not to be generally red
Red spotted	As for black spotted, but majority of spots and streaks are red

* Iyer, *Proc. Indian Sci. Congr.*, 1952, pt II, 124.

TABLE 5—STANDARD GRADING FOR MUSCOVITE BLOCKS, THINS AND FILMS*

Grade or Number (old system)	Size† (present system)	Area of usable rectangle (sq. cm.)	Minimum dimension of one side of usable rectangle (cm.)	Permissible strip tolerance
OOEE Special	630	645.2 and above	10.2	nil
OEE Special	500	516.1–645.2	10.2	nil
EE Special	400	387.1–516.1	10.2	nil
E Special	315	309.7–387.1	10.2	nil
Special	250	232.3–309.7	8.9	nil
1	160	154.8–232.3	7.6	5% of pieces having width down to 5.1 cm
2	100	96.8–154.8	5.1	5% of pieces having width down to 3.8 cm.
3	63	64.5–96.8	5.1	5% of pieces having width down to 3.8 cm.
4	40	38.7–64.5	3.8	5% of pieces having width down to 2.5 cm.
5	20	19.4–38.7	2.5	nil
5.5	16	14.5–19.4	2.2	nil
6	06	6.4–14.5	1.9	nil
7	05	4.8–6.4	1.6	nil

*IS: 1175–1957.
†This system should be considered as a first step towards a unified classification of all forms of mica based on a series of preferred numbers (IS: 1076–1957).

Second Quality, and Green/Brown Stained or BQ. The requirements of each of these categories have been specified. A set of Master Standard Samples of each of the 16 categories has been prepared and kept at the Geological Survey of India (G.S.I.), Calcutta, for comparison. Copies of the master standard are supplied by G.S.I. on request.

A mica grading apparatus is being developed by the Central Glass and Ceramics Research Institute, Calcutta, for testing and evaluating the electrical qualities of block mica. By the use of this instrument, it will be possible to classify mica rapidly on the basis of electrical properties and thus evaluate the suitability for electrical industries of even spotted or stained mica, which would have been otherwise rejected on the basis of conventional methods of visual inspection.

Marketing

Over 80% of the mica mined in India is lost as scrap during the process of rifting into sheets; a further loss of 45–60% occurs while shaping sheets into various components. Thus 85–90% of mined mica is wasted during the various stages of processing; wastage in other mica-producing countries is reported to be even higher; it is 90–95% in U.S.A., 95% in Brazil, 95–98% in Canada and 96–97% in East Africa (Roy, *J. Sci. Club, Calcutta*, 1958–59, **12**, 63).

Mica is marketed as block, condenser films, *chillas*, splittings and scrap. Block mica, sorted according to size and quality, is packed for export purposes in wooden boxes weighing 125, 112 or 100 lb. net; superior qualities and large sizes are shipped in 50 lb. boxes.

Laminae removed during the dressing or redressing of large blocks are sold as *chillas* or cleanings. Large sized *chillas* are suitable for the production of loose splittings.

Splittings are wrapped in paper and packed in 2–5 lb. packets; splittings packed in this manner are known as book-packed splittings. They are exported in boxes weighing 150, 125, 112, 100 or 50 lb. net. According to IS: 1174–1957, the minimum number of splittings in a book shall be not less than 4 and all such books shall contain only sound splittings. Pan-packed splittings are also produced occasionally; layers of splittings are spread in a tin dish, 7 in. diam. × 2 in. depth, until a compressed thickness of 1/16 in. is attained. Each group of films is separated by a circle of paper, to facilitate handling by hand-made micanite board manufacturers. Pan-packed splittings are not much in demand, as manufacturers find difficulty in separating individual films.

Splittings of heterogeneous shapes are packed loosely in boxes, with or without dusting.

Mica from Bihar and Rajasthan is marketed from Kodarma and Giridih, mainly in the form of mixed cut and assorted block. The splitting industry in Bihar is chiefly controlled by a few large firms, e.g. *Chrestien Mica Industries Ltd.*, Domchanch (Dist. Hazaribagh); *Chatturam Horilram*, Jhumri-Telaiya (Dist. Hazaribagh), and the *India Mica Supply Co.*, Giridih. These and a few other firms make mica washers and condenser plates. Nellore mica is exported from Madras by the *South India Export Co.* and by *Chambers & Co.* (Coggin Brown & Dey, 545).

Production and Trade

Table 6 gives the production of crude mica and dressed mica in recent years. State-wise break-up figures of crude mica and dressed mica are given in Tables 7 and 8.

TABLE 6—PRODUCTION OF CRUDE AND DRESSED MICA
(Qty in cwt.; val. in thousand Rs.)

	Crude		Dressed	
	Qty	Val.	Qty	Val.
1950	n.a.	n.a.	138,685	19,014
1951	n.a.	n.a.	194,976	29,441
1952	n.a.	n.a.	151,288	20,696
1953	n.a.	n.a.	128,503	16,962
1954	n.a.	n.a.	104,477	15,849
1955	465,014	29,570	109,823	18,303
1956	560,685	21,320	118,095	22,050
1957	609,082	23,154	106,319	19,665
1958	628,745	25,301	126,190	26,092
1959	567,808	24,376	118,000	24,941
1960†	570,900	24,571	112,770	n.a.

n.a. not available.
†Provisional.

TABLE 7—STATE-WISE PRODUCTION OF CRUDE MICA *
(Qty in cwt.; val. in thousand Rs.)

	1957		1958		1959		1960†	
	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.
Andhra Pradesh								
Nellore	103,976	2,111	102,317	2,077	115,256	2,823	137,256[a]	3,737[a]
Bihar								
Gaya	47,039	1,152	46,257	2,120	24,251	1,251	28,858[b]	1,466[b]
Hazaribagh	287,762	13,459	335,750	15,374	289,985	15,080	249,280	13,551
Monghyr	10,961	244	12,086	554	7,362	518	8,012	460
Total	345,762	14,855	394,093	18,048	321,598	16,849	286,150	15,431
Madras								
Nilgiris	10,844	304	5,157	145	3,484	188	2,444	130
Rajasthan								
Ajmer	15,350	606	15,668	623	7,775	267	7,676	270
Bhilwara	128,594	5,114	107,317	4,265	110,112	3,982	122,948	4,516
Jaipur	146	6	1,319	52	4,035	137	7,066	254
Udaipur	2,787	111	925	37	1,850	59	1,634	58
Tonk	160	6	..	..	1,063	36	4,014[c]	146[c]
Total	147,037	5,843	125,229	4,977	124,815	4,373	143,338	5,244
Others	1,463	41	1,949	54	2,705	35	1,712	29
Grand Total	609,082	23,154	628,745	25,301	567,808	24,376	570,900	24,571

* *Mineral Production in India*, Indian Bureau of Mines, 1957; Provisional Estimate of Mineral Production in India 1959, 1960
† Provisional.
[a] Includes 98 cwt. (val. Rs. 3,000) from Vishakapatnam dist.
[b] Includes 2,066 cwt. (val. Rs. 115,000) from Bhagalpur dist.
[c] Includes 118 cwt. (val. Rs. 5,000) from Sikar dist.

TABLE 8—STATE-WISE PRODUCTION OF DRESSED MICA *
(Qty in cwt.; val. in thousand Rs.)

	1957				1958		1959	
	Sickle dressed blocks		Chillas					
	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.
Andhra Pradesh								
Nellore	10,850	2,540	3,470	122	14,920	4,181	16,672	4,675
Bihar								
Gaya	3,339	441	120	3	3,288	579	2,006	417
Hazaribagh	46,496	8,402	2,616	61	74,188	13,075	49,780	9,689
Monghyr	2,679	354	84	2	1,024	180	846	175
Total	52,514	9,197	2,820	66	78,500	13,834	52,632	10,281
Kerala								
Quilon	42†	7	16	2	78	12	688	52
Madras								
Nilgiris	620	209	637	34	452	87	334	120
Rajasthan								
Ajmer	2,799	532	640	44	4,092	1,013	2,520	549
Bhilwara	29,487	6,649	1,716	111	27,794	6,877	43,382	8,856
Jaipur	31	7	1	..	..	..	984	228
Udaipur	612	138	21	1	354	88	512	120
Tonk	37	7	6	..	..	..	276	60
Total	32,966	7,333	2,384	159	32,240	7,978	47,674	9,813
GRAND TOTAL	96,992	19,286	9,327	383	126,190	26,092	118,000	24,941

* *Mineral Production in India*, Indian Bureau of Mines, 1957, annexures, 13; Indian Minerals Yearb., 1959, 237.
† Includes 1 cwt. from Balaghat (Madhya Pradesh).

TABLE 9—EXPORTS OF BLOCK, SPLITTINGS AND WASTE MICA FROM INDIA
(Qty in cwt.; val. in thousand Rs.)

	Block		Splittings		Waste, etc.		Total	
	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.
1948-49	12,134	8,365	200,174	50,285	127,949	724	340,257	59,374
1949-50	8,827	9,523	207,524	58,403	81,375	533	297,726	68,458
1950-51	21,248	18,922	248,440	80,325	137,017	799	406,705	100,046
1951-52	32,778	43,958	230,503	87,154	144,385	981	407,666	132,094
1952-53	27,882	40,591	101,252	48,607	154,968	918	284,102	90,117
1953-54	34,065	42,948	106,260	36,388	114,413	634	257,738	79,970
1954-55	35,300	36,803	108,204	29,281	229,[illegible]00	1,155	372,804	67,239
1955-56	105,120	47,640	148,878	34,760	265,303	1,312	519,301	83,712
1956 (April-Dec.)	38,391	36,183	97,151	28,670	153,149	832	288,691	65,685
1957	39,380	36,546	148,255	46,976	252,837	3,112	440,472	86,634
1958	46,826	44,792	127,368	47,015	214,300	1,648	388,494	93,455
1959	56,307	52,563	142,757	47,978	261,105	2,607	460,169	103,148
1960-61	44,972.4	41,291	162,092.7	57,926	252,996.3	2,323	560,061.4	101,540

The output of dressed mica given in official publications is lower than actual exports of blocks and splittings due to the fact that small producers do not send returns of their output of dressed mica. Export figures give a truer index of actual production.

The present consumption of mica in India is estimated at 10,000 lb. per annum. The major portion is used in the manufacture of mica insulating bricks; consumption as ground mica and micanite comes next. With the development of electrical industries, the consumption of mica sheets and built-up micanite is expected to increase substantially.

Exports—Table 9 gives the exports of block, splittings and scrap mica from 1948 to 1960–61. Exports of different categories of mica during 1958, 1959, and 1960-61 are given in Table 10.

The Indian mica industry is facing serious competition from Brazil and other mica-producing countries. The Government of India have recently set up an Export Promotion Council to increase and promote the exports of mica, mica manufactures and by-products of the mica industry. The Council has set up an inspectorate to examine the quality of mica before shipment on the basis of samples sent to it by buyers. The principal importers of Indian mica during 1959 were: U.S.A., U.K., Japan, Germany, U.S.S.R., Italy and France; their offtakes were respectively, 33, 15, 13, 12, 7, 3 and 3% of the total exports. The balance of 14% was imported by other European countries. A cess at the rate of 2½% *ad valorem* is levied on exported mica, and the money so realized is utilized for labour welfare.

Import—A small amount of uncut and unmanufactured mica, sometimes also ground mica is imported into India. Table 11 gives imports from 1948 to 1960 61. Imports of mica products during 1957, 1958, 1959 and 1960 61 were valued at Rs. 102,333, Rs. 79,785, Rs. 56,020 and Rs. 51,940 respectively.

Prices—The prices for different qualities and sizes of mica vary considerably. Block mica of clear quality, especially from Bihar, fetches higher prices than other qualities produced in India and elsewhere. Table 12 gives the prices of various grades of block mica, splittings and loose mica f.o.b. Calcutta during 1956 60.

TABLE 10—EXPORTS OF DIFFERENT CATEGORIES OF MICA FROM 1958 TO 1960-61

(Qty in cwt.; val. in thousand Rs.)

	1958		1959		1960 61	
Block mica	Qty	Val.	Qty	Val.	Qty	Val.
Bihar						
Superfine	122	122	38	45	99.3	98
Clear	102	622	158	868	158.0	573
Fair stained	599	1,790	652	2,060	374.9	822
Good stained	2,475	5,190	2,360	4,728	2,828.1	7,533
Stained	24,585	21,875	27,342	25,140	20,413.5	17,771
Heavy stained	4,259	3,732	5,208	5,162	1,238.0	1,392
Lower than heavy stained	3,127	1,623	2,059	1,012	2,624.2	1,347
Andhra (Madras)						
Ruby	2,766	2,766	2,103	2,464	1,673.9	1,277
Green	926	1,355	2,006	1,865	1,794.7	1,999
Spotted	3,889	2,558	4,994	2,799	3,613.5	2,314
Travancore						
Phlogopite	18	5	28	9	26.8	9
Others (not elsewhere specified)	3,958	3,154	9,359	6,411	10,127.5	6,156
Total	46,826	44,792	56,307	52,563	44,972.4	41,291

TABLE 10—*contd.*

	1958 Qty	1958 Val.	1959 Qty	1959 Val.	1960-61 Qty	1960-61 Val.
Splittings						
Bihar						
Book form	16,146	16,565	17,261	16,835	19,707.2	20,404
Pan Packed	522	652	137	126	4.0	6
Dusted Loose	28,979	12,028	16,034	6,660	23,037.8	9,622
Loose	54,686	8,247	71,484	8,611	75,824.7	14,199
Andhra (Madras)						
Book form	3,532	3,101	3,673	3,226	7,379.5	5,344
Dusted Loose	9,121	3,605	7,686	2,840	11,065.7	4,067
Loose	9,223	1,268	10,116	1,412	18,616.6	2,433
Travancore						
Phlogopite	840	331	452	156	757.4	240
Others (not elsewhere specified)	4,319	1,218	15,814	8,112	4,699.8	1,611
Total	127,368	47,015	142,757	47,978	162,097.7	57,926
Ground Scrap, Waste, etc.						
Bihar—Ground scrap and waste	139,213	783	172,678	997	191,181.3	1,212
Bihar mica wrappers uncut, etc.	72	34	7	16	2.0	27
Madras waste scrap	74,583	304	86,982	362	160,451.5	723
Travancore mica, other than blocks and splittings	..	..	116	55	..	..
Ground mica not specified	3	neg.	1	neg.	1,006.3	6
Other mica uncut, unmanufactured	429	527	1,321	1,177	355.2	355
Total	214,300	1,648	261,105	2,607	352,996.3	2,323
GRAND TOTAL	388,494	93,455	460,169	103,148	560,061.4	101,540

neg.—negligible

TABLE 11—IMPORTS OF UNMANUFACTURED MICA
(Qty in cwt.; val. in Rs.)

	Qty	Val.
1948-49	3,840	12,83,798
1949-50	1,022	7,58,018
1950-51	5,133	34,26,700
1951-52	1,629	5,69,125
1952-53	379	1,66,403
1953-54	698	6,35,410
1954-55	1,227	5,66,354
1955-56	3,156	3,72,939
1956 (April-Dec.)	109	83,265
1957	1,969	2,99,084
1958	237	16,454
1959	5	301
1960-61	272	18,769

TABLE 12—PRICES OF DIFFERENT QUALITIES OF MICA DURING 1956-60
(Rs. per lb.)

		1956	1957	1958	1959	1960
Block mica						
Clear & slightly stained	No. 1	96.00	109.00	112.58	117.16	112.95
do.	No. 5	51.00	52.12	50.58	52.30	52.18
Fairly stained	No. 1	53.00	79.43	80.92	84.25	83.65
do.	No. 5	34.50	44.54	44.25	44.00	44.43
Stained	No. 1	34.00	37.45	33.35	34.00	34.64
do.	No. 5	12.00	14.67	12.87	13.40	13.64
Mica splittings						
Book form	No. 4	12.10	12.00	12.25	13.25	15.15
do.	No. 5	10.00	9.50	9.25	10.13	12.54
do.	No. 6	4.10	4.09	4.13	3.82	4.64
Dusted loose	No. 6	1.85	1.39	1.26	1.30	1.52
Mica (loose)						
1st quality	..	1.25	1.05	0.95	0.98	1.03
2nd quality	..	0.90	0.75	0.73	0.73	0.66

Mice — *see* **Rats and Other Rodents**

MICHELIA Linn. (*Magnoliaceae*)

A genus of trees and shrubs distributed in South-East Asia and China. About 14 species are found in India. Many of them yield timbers resembling Canary Wood of America in appearance and general structure. Some are ornamental.

M. cathcartii Hook. f. & Thoms.= *Alcimandra cathcartii* (Hook. f. & Thoms.) Dandy

D.E.P., V, 241 ; Fl. Br. Ind., I, 42 ; King, *Ann. R. bot. Gdn Calcutta*, 1891, **3**, 214, Pl. 60.

Nepal—*Kala champ, tite champ* ; Lepcha—*Atok-dung, gokdum* ; Khasi—*Dieng-rai*.

An evergreen tree, up to 24 m. in height and 2.5 m. in girth, with a bole up to 9 m. long, found in eastern Himalayas and Assam hills at altitudes of 1,500–2,100 m. Bark dark grey or brown ; leaves oblong-lanceolate or lanceolate, sub-coriaceous ; flowers mostly terminal, white ; fruit cylindrical, 7.5–12.5 cm. long ; ripe carpels sub-orbicular, compressed.

The wood of *M. cathcartii* is moderately hard, light (wt., 33 lb./cu. ft.) and easy to work. It is not very durable ; graveyard tests indicate a natural durability of 2–5 years. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are : wt., 75 ; strength as a beam, 65 ; stiffness as a beam, 90 ; suitability as a post, 75 ; shock-resisting ability, 75 ; retention of shape, 65 ; shear, 95 ; and hardness, 55. The timber is suitable for planking, tea boxes and indoor work. It has also been found suitable for aircraft construction [Cowan & Cowan, 9 ; Purushotham *et al.*, *Indian For.*, 1953, **79**, 49 ; Limaye, *Indian For. Rec.*, *N.S.*, *Util.*, 1944, **3**(5), 20 ; Bor, 43 ; Limaye, *Indian For. Leafl.*, No. 17, 1942].

M. champaca Linn. Champak

D.E.P., V, 241 ; Fl. Br. Ind., I, 42 ; King, *Ann. R. bot. Gdn Calcutta*, 1891, **3**, 216, Pl. 64.

Hindi & Beng.—*Champa, champaca* ; Mar.—*Pivala-champa, sona-champa, kud-champa* ; Guj.—*Champo, rae-champo, pito-champo* ; Tel.—*Champakamu* ; Tam.—*Shembuga, chambugam* ; Kan.—*Sampige, kola-sampige* ; Mal.—*Champakam* ; Oriya—*Chompa, chompoko, kanchana*.

Nepal—*Ouliachamp* ; Assam—*Titasopa, bolnabat, shap*.

Trade—*Champak*.

A tall, evergreen tree, usually up to 30 m. in height and 3.5 m. in girth, with a clean cylindrical bole up

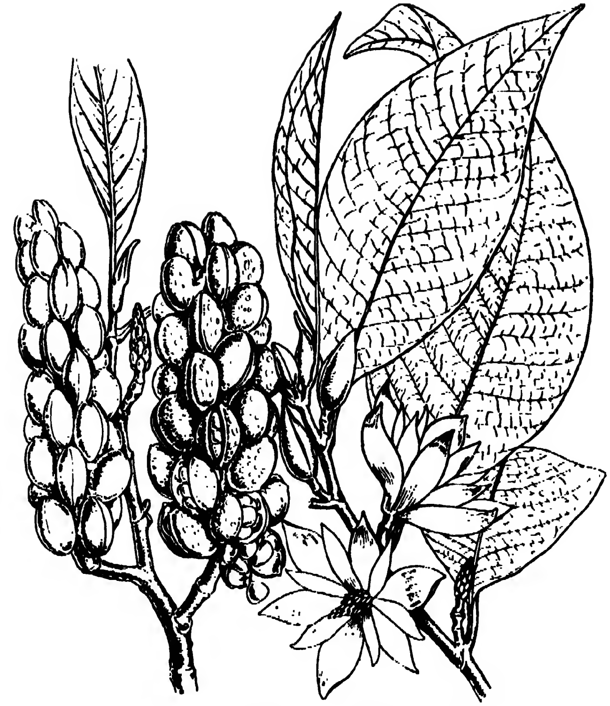


FIG. 136. MICHELIA CHAMPACA—FLOWERING AND FRUITING BRANCH

to 20 m. long, found in eastern Himalayas, north-east India and western ghats. It is cultivated throughout India in gardens and near temples for its fragrant flowers and handsome foliage. Bark grey or brownish ; leaves ovate to lanceolate, coriaceous ; flowers usually axillary, solitary, yellow or orange, fragrant ; fruit 5–10 cm. long ; ripe carpels ovoid or ellipsoid, woody ; seeds brown, angular, with pink fleshy aril.

The tree thrives best in a damp climate and requires deep moist soil. It is a moderate light demander and is sensitive to frost. Natural regeneration is usually plentiful around mother trees. The tree flowers in hot and rainy weather and seeds late in August, which is too late for direct sowing, and seeds have low viability. Artificial reproduction is, therefore, accomplished by sowing fresh seeds in the nursery and transplanting 12–15 months old seedlings. Root and shoot cuttings may also be used ; stump planting has been successful in some places. The tree coppices well. The rate of growth is fast, the mean annual girth increment being *c.* 1 inch (Troup, I, 8 ; *FAO For. Developm. Pap.*, Rome, No. 11, 1957, 144 ; *Indian For.*, 1952, **78**, 358 ; Kadambi & Dabral, ibid., 1955, **81**, 129).

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MICHELIA CHAMPACA — PLANTATION

The wood is yellowish to olive brown, somewhat lustrous, smooth, straight-grained, medium-textured, soft and light (sp. gr., *c.* 0.53 ; wt., 31–34 lb./cu. ft.). The best results in seasoning are obtained by girdling standing trees for two and half years, followed by conversion and seasoning in the plank or scantling for six months. Kiln-seasoning also gives satisfactory results, though the timber becomes dull during the process (Pearson & Brown, I, 17–19).

The timber is not very durable, although there are records of its having lasted well in the ground and in water ; graveyard tests indicate an average life of 5 years or less. The heartwood is refractory to treatment, side and end penetration of preservatives being practically nil. The timber is easy to saw, works to a smooth surface and takes a good polish. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 70 ; strength as a beam, 70 ; stiffness as a beam, 75 ; suitability as a post, 70 ; shock-resisting ability, 75 ; retention of shape, 90 ; shear, 85 ; and hardness, 65 [Pearson & Brown, I, 19 ; IS: 399, 1952, 32 ; Limaye, *Indian For. Rec., N.S., Util.*, 1944, **3**(5), 20].

The wood is used for posts, boards, veneers, furniture, decorative fittings, carving and carriage and ship building. It is also used for bent-wood ribs, general joinery work, bobbins, drums, toys and beads. It is suitable for making pencils, particularly after impregnating the slats with paraffin wax. It is suitable for aircraft construction, battery separators and tea chest plywood. It is classed among good fuel woods ; calorific value: *sapwood*—5,042 cal., 9,076 B.t.u. ; *heartwood*—5,093 cal., 9,168 B.t.u. (Pearson & Brown, I, 19 ; Gamble, 12 ; Dastur, Useful Plants, 150 ; Rehman & Askari, *Indian For.*, 1956, **82,** 314 ; Rehman & Jai Kishen, ibid., 1951, **77,** 699 ; Limaye, *Indian For. Leafl.*, No. 17, 1942 ; Rehman & Ishaq, *Indian For. Bull., N.S.*, No. 124, 1944 ; *Indian For.*, 1952, **78,** 276 ; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 20).

M. champaca is cultivated on a small scale in Reunion Island and Madagascar for the production of Champa Oil or Champaca Oil, highly esteemed in perfumery. It is obtained from the flowers in the form of a concrete, by extraction with petroleum ether ; the perfume may also be extracted by enfleurage. Steam-distillation gives poor yields and the oil obtained is reported to be inferior as it gets polymerized. The yield of concrete, by the extraction of flowers with petroleum ether is reported to vary from 0.16 to 0.20% in Reunion Island and from 0.13 to 0.15% in Madagascar ; the concrete gives *c.* 50% absolute. The characteristics of the volatile oil prepared from the concrete by co-distillation with glycol are: sp. gr.$^{15°}$, 0.946 ; $n^{20°}$, 1.4895 ; acid val., 6.2 ; ester val., 70.1 ; and carbonyl val., 42.3 (cold method), 65 (hot method) [Guenther, V, 379–81 ; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(2), suppl., 15 ; Gupta *et al.*, *Symp. Res. Developm. essent. Oil Ind. India*, Oil Technol. Ass. India, 1954, 28].

Champac flowers are employed in India in the preparation of attars and perfumed hair oils. Champa oil has been produced on an experimental scale : extraction of flowers with benzene gave 0.26% concrete (m.p. 29° ; congealing pt., 28° ; acid val., 29.1 ; and sap. val., 177.2) which on steam-distillation yielded 26.3% of a volatile oil. The oil obtained by water-distillation (yield, 0.064–0.067%) of flowers had the following physico-chemical properties (two samples): sp. gr.$^{30°}$, 0.9930, 0.9614 ; $[\alpha]_D$, $+7.2°$; $n^{30°}$, 1.4959, 1.4925 ; acid val., 6.22, 4.17 ; sap. val., 77.23, 69.02 ; ester val., 71.01, 64.84 ; ester val. after acetylation, 120.8, 129.8 ; sol. in 1 vol. of 90% alcohol, becoming turbid with more. The oil does not resinify on fractionation ; it contains cineole, *iso*-eugenol, benzaldehyde, phenyl ethyl alcohol and methyl anthranilate (Dhingra, 28–29).

Champa oil has a delightful velvety odour closely approximating to that of the flower and recalling the fragrance of tea, orange blossoms and ylang ylang. It constitutes one of the most exquisite raw materials for perfumery, being used in some of the finest French creations. Genuine concrete is produced in very small quantities and commercial champa perfumes are mostly synthetic (Guenther, V, 381 ; Poucher, I, 112).

The leaves on distillation yield 0.04% of a volatile oil with an odour reminiscent of basil (from *Ocimum basilicum* Linn.). It is reported to be produced in Java on a commercial scale : it has the following characteristics: sp. gr., 0.922 ; $[\alpha]_D$, $+12.5°$; acid val., 1.9 ; sap. val., 15.2 ; and sap. val. after acetylation, 63.5 (Poucher, I, 112 ; Parry, I, 511).

The seeds contain 32.2% of a fat, a resin and resin acids. The fat has the following characteristics: m.p. 44–45° ; sp. gr.$^{18°}$, 0.903 ; acid val., 52.6 ; sap. val., 196–99 ; and iod. val., 60.3. The component fatty acids are: palmitic, 30 ; and oleic, 70%. The seed fat is used in medicine [Wehmer, I, 336 ; Krishna *et al.*, *Indian For. Rec., N.S., Chem.*, 1936, **1**(1), 39].

The fruits are reported to be eaten. The bark contains alkaloids (0.3%) and tannins; it is chewed with betel and also used as an adulterant of cinnamon. The flowers yield a yellow dye used for dyeing textiles. A variety of silkworm is sometimes reared on the tree (*Rep. sci. adv. Bd*, Indian Coun. med. Res., 1950, 325; Neal, 308; Trotter, 1940, 280).

The bark of champac tree is considered stimulant, diuretic and febrifuge; dried root and root bark are purgative and emmenagogue. The juice of the leaves is used in colic. Flowers and fruits are stimulant, antispasmodic, stomachic and diuretic and are considered useful in dyspepsia, fever and in renal diseases. The flower oil is used as an application in cephalalgia, ophthalmia, gout and rheumatism. Fruits and seeds are considered useful for healing cracks in feet (Chopra, 1958, 514; Burkill, II, 1465; Quisumbing, 304–05).

M. doltsopa Buch.-Ham. ex DC. syn. *M. excelsa* Blume; *M. manipurensis* Watt ex Brandis

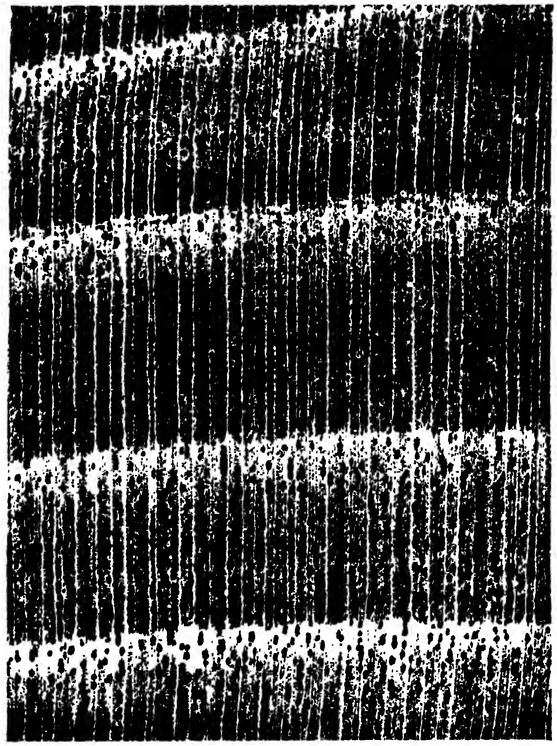
D.E.P., V, 243; Fl. Br. Ind., I, 43; King, *Ann. R. bot. Gdn Calcutta*, 1891, **3**, 215, Pl. 63.

Nepal—*Bara champ, safed champ;* Lepcha—*Sigugrip, pendere;* Khasi—*Dieng-rai.*

A deciduous tree up to 36 m. in height and 4.5 m. in girth, with a straight clean bole up to 15 m. long, found in central and eastern Himalayas and Khasi hills up to an altitude of 2,400 m.: it is reported to be cultivated in Darjeeling and Ootacamund. Bark grey or brownish, corky outside; leaves oblong, oblong-lanceolate or ovate-elliptic; flowers mostly axillary, white, fragrant; fruit 12.5–20.0 cm. long: ripe carpels obliquely ovoid, beaked; seed oily with red aril.

The tree grows on hill sides or ridges and prefers deep loamy soils; it also grows on moderately clayey soil, but bad drainage and excessive soil moisture produce stunted growth. The tree is a light demander and is frost-hardy. It coppices well up to a fair size (Troup, I, 5).

Natural reproduction is plentiful and is sometimes obtained by opening the canopy in the vicinity of seed-bearers. Artificial reproduction is carried out by transplanting 3–4 year old (2–3 ft. high), nursery-raised seedlings. Seeds have a low viability and are sown soon after the ripening of fruits in November. Transplanting is carried out in the rainy season and a spacing of 10 ft. × 10 ft. is considered sufficient. Fencing against deer and weeding twice a year for the first three years are considered necessary. The mean annual girth increment is reported to be 0.7 in. (Troup, I, 6).



F.R.I., Dehra Dun. Photo: S. S. Ghosh

FIG. 137. MICHELIA DOLTSOPA—TRANSVERSE SECTION OF WOOD (× 10)

The wood is similar to champac but has a finer texture; it is straight-grained, soft and light (sp. gr., *c.* 0.56; wt., 32 lb./cu.ft.). The timber seasons well and is reported to be durable under cover; graveyard tests indicated a natural durability of only 2 years or less. The heartwood is refractory to treatment, side and end penetration of preservatives being practically nil. The timber is easy to saw and work to a smooth glossy surface; it shows a beautiful straight grain. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 75; strength as a beam, 75; stiffness as a beam, 90; suitability as a post, 80; shock-resisting ability, 75; retention of shape, 65; shear, 65; and hardness, 60 [Pearson & Brown, 1, 15–16; Limaye, *Indian For. Rec., N. S., Util.*, 1944, **3**(5), 20; Purushotham *et al.*, *Indian For.*, 1953, **79**, 49].

The wood is used for door and window frames, ceiling boards, furniture, planking, rafters and tea boxes. It is considered suitable for aircraft construction, bobbins, jute mill rollers and disks and

for second grade pencils. The bark contains 6% tannin [Pearson & Brown, I, 16; Rehman & Ishaq, *Indian For. Leafl.*, No. 66, 1945; Rehman, *Indian For. Bull., N. S.*, No. 122, 1943; Limaye, *Indian For. Leafl.*, No. 17, 1942; Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1** (2), 153].

M. montana Blume

Fl. Assam, I, 25; King, *Ann. R. bot. Gdn Calcutta*, 1891, **3**, 218, Pl. 68.

Assam—*Pan sopa.*

An evergreen tree found in eastern Himalayas and hills of Assam. Bark grey with horizontal wrinkles; leaves ovate, elliptic or obovate, coriaceous; flowers axillary or terminal, white, fragrant; ripe carpels obovoid, woody; seeds 3–5, reddish brown.

The tree can be propagated by transplanting nursery-raised seedlings during the first rainy season at a distance of 8 ft. × 8 ft.; transplanting during winter has also proved successful (Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 162).

The wood is light (wt., 32 lb./cu. ft.) and durable; graveyard tests indicate a natural durability of 10–15 years. The data for the comparative suitability of the timber, expressed as percentage of the same properties of teak, are: wt., 75; strength as a beam, 70; stiffness as a beam, 75; suitability as a post, 70; shock-resisting ability, 75; retention of shape, 80; shear, 85; and hardness, 65 [Purushotham *et al.*, *Indian For.*, 1953, **79**, 49; Limaye, *Indian For. Rec., N.S., Util.*, 1944, **3**(5), 22].

The wood is suitable for house building, bridges and furniture. The bark is aromatic and used as a bitter tonic in fevers [Burkill, II, 1967; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(2), suppl., 15; Kirt. & Basu, I, 59].

M. nilagirica Zenker

D.E.P., V, 244; Fl. Br. Ind., I, 44; King, *Ann. R. bot. Gdn Calcutta*, 1891, **3**, 216, Pl. 65.

Tam.—*Shembuga, kattu shambagam*; Kan.—*Bilisampage, doddasampage.*

A tree or a shrub found in the Nilgiris, Anaimalai and Palni hills at altitudes of 1,500–1,800 m. Leaves elliptic or obovate-lanceolate; flowers axillary, white or creamish; fruit 7.5–10 cm. long; ripe carpels warty; seeds red.

The wood is moderately hard and heavy (sp. gr., *c.* 0.64; wt., 41. lb./cu. ft.). It is said to season well and is durable. It can be sawn without difficulty and works to a shiny smooth surface. It is used for doors and windows, beams, rafters and panels; it is suitable for furniture. It is reported to be used also for railway sleepers (Pearson & Brown, I, 19–20; Lewis, 4).

The bark and leaves of the tree are considered febrifuge. The bark contains a volatile oil, acrid resins, tannin and a bitter principle. The flowers yield a volatile oil similar to the bark oil (Gamble, 13; Wehmer, I, 336).

M. oblonga Wall. ex Hook. f. & Thoms.

D.E.P., V, 244; Fl. Br. Ind., I, 43; King, *Ann. R. bot. Gdn Calcutta*, 1891, **3**, 217, Pl. 67.

Assam—*Phul-sopa, bor-sopa, kothal-sopa*; Khasi—*Dieng-ta-roi*; Garo—*Chambisersang, bewa-chhamphe.*

A lofty tree, up to 45 m. in height and 4.2 m. in girth, with a bole 24 m. long, generally buttressed at the base, found in Assam. Bark grey, rough and warty, aromatic; leaves oblanceolate or ovate, thinly coriaceous; flowers axillary, whitish, scarcely scented; fruit 15.0–17.5 cm. long; ripe carpels lax, obovoid.

The tree can be propagated by transplanting nursery-raised seedlings; winter transplanting has given almost 100% survivals (Kadambi & Dabral, *Indian For.*, 1955, **81**, 129).

The wood is greyish white, fine-grained and light. It is reported to season well without warping or splitting. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 65; strength as a beam, 50; stiffness as a beam, 60; suitability as a post, 50; shock-resisting ability, 65; retention of shape, 80; shear, 70; and hardness, 45. The wood is used for planking, rough furniture, cabinet work and canoes; it is used for tea chests. It is also considered suitable for aircraft construction [Gamble, 13; Fl. Assam, I, 25; Limaye, *Indian For. Rec., N.S., Util.*, 1944, **3**(5), 22; *Indian For. Leafl.*, No. 17, 1942].

M. baillonii Finet & Gagnep. syn. *Talauma phellocarpa* King; *T. spongocarpa* King (Assam—*Titasopa, khorika-sopa*; Kachar—*Karo-phang*; Garo—*Bol-mring*) is an evergreen tree, up to 30 m. in height and 2.4 m. in girth, with aromatic bark, found in Assam and Khasi hills up to an altitude of 1,200 m. It can be artificially propagated by means of entire transplants (Kadambi & Dabral, *Indian For.*, 1955, **81**, 129).

The wood (wt., 43 lb./cu.ft.) is moderately refractory to air-seasoning and takes a good polish. It is

used for planking, doors and windows, furniture, panels, packing cases, turnery articles and toys (IS: 399, 1952, 13, 16, 17; Gamble, 8; Fl. Assam, I, 19).

M. figo (Lour.) Spreng. syn. *M. fuscata* Blume; *Magnolia fuscata* Andr. is a handsome evergreen shrub or a small tree with elliptic-lanceolate or oblong leaves and brownish yellow fragrant flowers, often cultivated for ornament. In China, the flowers are used in perfumery and for scenting tea. On extraction with petroleum ether, they yield 0.17% of a dark brown concrete from which a dark brown volatile oil (0.06%) and a pale yellow wax (0.11%) have been prepared. The wood is used in Java for kris-handles and sheaths (Burkill, II, 1466; Bor, 43; Corner, I, 434; Yeh, *Perfum. essent. Oil Rec.*, 1958, **49,** 69).

The leaves contain 1.5–2.0% of total alkaloids, of which magnoline ($C_{36}H_{40}O_6N_2$, m.p. 178–79°) and magnolamine (hydroxymagnoline, $C_{36}H_{40}O_7N_2$, m.p. 117–19°), belonging to the bisbenzyl *iso*-quinoline group, have been identified. Magnoline exerts hypotensive effects and also possesses anticholinesterase activity. Magnolamine acts as cardiac depressant (Henry, 354–55; *Chem. Abstr.*, 1959, **53,** 5505).

M. kisopa Buch.-Ham. ex DC. (Kumaon—*Garuri, kanjira*; Nepal—*Chobsi*) is a tree, up to 37 m. in height and 3 m. in girth, found in the Himalayas from Kumaon to Sikkim at altitudes of 1,500–2,100 m.; it is reported to be cultivated in Shillong. It bears pale yellow flowers which are delightfully scented. The wood is yellowish and is used for light construction, planking, door frames, etc. [Gamble, 10–11; Fl. Assam, I, 23; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(2), suppl., 15].

M. lanuginosa Wall. (Nepal—*Gogoi-champ*; Lepcha—*Phusre, guay-champ*; Khasi—*Dieng-lali*) is a tree, up to 27 m. in height and 2 m. in girth, found in temperate Himalayas from Nepal to Bhutan and Khasi hills at altitudes of 1,500–2,100 m. It is a fast growing species and has been recommended for cultivation in tea estates for timber and fuel. The wood is greyish white and light (wt., 27–36 lb./cu. ft.); it is suitable for planking and for making charcoal (Gamble, 11; Fl. Assam, I, 22; Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 144).

M. punduana Hook. f. & Thoms. (Khasi—*Dieng-soh-niar*) is a medium-sized to tall tree found in eastern Himalayas and Khasi hills at altitudes of 900–1,800 m. The wood is dull grey and light (wt., *c.* 37 lb./cu. ft.). It is not liable to warp and split and is considered suitable for planking and furniture. The inner bark is aromatic (Fl. Assam, I, 24; Krishna & Badhwar, loc. cit.).

Micrococos — *see* **Grewia**

MICROGLOSSA DC. (*Compositae*)

A small genus of shrubs and shrubby climbers distributed in warmer parts of Africa and Asia. Three species occur in India.

M. pyrifolia (Lam.) Kuntze syn. *M. volubilis* DC.
Fl. Br. Ind., III, 257.

A large scandent shrub found in Manipur and the Khasi, Jaintia, Naga, Aka and Abor hills. Leaves ovate-lanceolate or ovate-elliptic, entire or distantly serrate; flower heads small, corymbose, white or yellow.

M. pyrifolia is much valued medicinally in tropical West Africa. It is given as an enema to cure fever in infants. A juice of roots is used as a specific for cataract. The powdered root is taken as a snuff to relieve colds. A tea-like infusion of the odorous leaves is taken for fever with headache; it is diaphoretic when taken as a lotion or fumigation or inhaled. A decoction of leaves is used as a specific for yellow fever and dropsy, and in the treatment of blackwater fever. A juice of the warmed leaves is applied in sore eyes and also used as a remedy for ringworm of the scalp (Dalziel, 419).

MICROMELUM Blume (*Rutaceae*)

A small genus of trees or shrubs distributed from India to Australia, New Caledonia and western Polynesia. Four species occur in India.

***M. pubescens** Blume; Hook. f. (Fl. Br. Ind.) in part
Fl. Br. Ind., I, 501; Swingle in Webber & Batchelor, I, 143, 149.

A shrub or small tree found in Andaman Islands. Leaves imparipinnate, large; leaflets ovate to broad lanceolate; flowers greenish-white, in many-flowered cymes; fruit a small, ovoid or oblong, yellow berry.

The plant is used medicinally in Malaya and Indonesia. It is recommended for phthisis and chest troubles. The root is chewed with betel for coughs. The boiled roots are applied as a poultice for ague. Leaves give positive tests with alkaloidal reagents [*J. sci. Res. Indonesia*, 1952, **1** (suppl.), 6; Burkill, II, 1469; Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 268, 1952, 86].

* Many authors consider *M. pubescens* Blume a synonym of *M. minutum* (Forst. f.) Seem. Swingle (Webber & Batchelor, I, 143, 149), however, regards them as distinct.

The wood is light and durable and is used for making house (Burkill, II, 1469).

M. hirsutum Oliver is a low shrub found in Andaman Islands. Leaves of the plant, pounded with tamarind and salt, are applied to the skin to remove pain and irritation caused by the sting of caterpillar (Burkill, II, 1468).

M. integerrimum (Buch.-Ham.) Roem. syn. *M. pubescens* Hook. f. (Fl. Br. Ind.) in part, non Blume, a species closely related to *M. minutum*, is found in Nepal, Sikkim, Bihar, Orissa, northern Bengal, Assam, Khasi, Aka and Lushai hills, N. Circars and the Andaman Islands. The bark of the root, stem and branches of this plant is used in the treatment of tubercular cases (Biswas, 42).

MICROMERIA Benth. (*Labiatae*)

A large genus of perennial herbs or undershrubs distributed in both the hemispheres. Three species occur in India.

M. biflora Benth. INDIAN WILD THYME

D.E.P., V, 244; Fl. Br. Ind., IV, 650; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 96; Fyson, II, Pl. 411.

MUNDARI *Ote budu ba.*

A dwarf herb, usually 5–10 cm. high, rarely up to 30 cm. high, found in tropical and temperate Himalayas from Kashmir to Bhutan and in Punjab (Gurdaspur), Bihar, N. Circars, western ghats and hills of S. India ascending up to 2,100 m. Leaves sessile or sub-sessile, ovate or oblong, sub-acute; flowers pink or blue in axillary cymes.

M. biflora is an aromatic herb reported to be used by Mundas as an application for worm-infested wounds of cattle. Four physiological types of the species – *camphorata*, *citrata*, *menthata* and *pulegata* – have been recently reported. The volatile oil contents of the types vary from 0.41% in *citrata* to 1.21% in *menthata*. All these oils are dextrorotatory. The principal constituent in one is camphor: it is citral in another, and *d*-menthone and pulegone in the other two (Bressers, 119; *Chem. Abstr.*, 1952, **46**, 11585).

M. capitellata Benth. (BOMBAY—*Karvat*; SANTAL –*Buru pudina*; MUNDARI –*Piri lajauni ba*) is an erect slender herb, 30–60 cm. high, found in Kumaon, upper Gangetic plain, Bihar, Orissa, N. Circars, Deccan, western ghats and Nilgiris ascending up to 1,800 m. The plant is aromatic and carminative; it is considered to be a good substitute for *Mentha piperita* Linn. (Kirt. & Basu, III, 1992).

MICROSTEGIUM Nees ex Lindl. (*Gramineae*)

A genus of annual or perennial grasses found in the hills and plains of India, and extending to Burma. About 5 species are recorded from India.

M. ciliatum A. Camus syn. *Pollinia ciliata* Trin.; *P. monantha* Nees ex Steud.; *M. monanthum* A. Camus

D.E.P., III, 437; Fl. Br. Ind., VII, 116; Fl. Assam, V, 327; Bor, *Indian For. Rec., N.S., Bot.*, 1941, **2**, 151, Pl. 37.

ASSAM –*Kharika, sau.*

An annual or perennial straggling grass with culms up to 120 cm. long, found in tropical and sub-tropical Himalayas, from Kumaon and Garhwal eastward to Assam and Khasi hills and southward in the hills of Orissa, Madras and Kerala. The grass grows in moist but not water-logged soils. It is often gregarious and covers large areas in forests under partial shade. It is commonly found as a thick undergrowth in sal (*Shorea robusta* Gaertn.) forests especially in the bhabar tract of Assam, where the soil and subsoil consist of an immense depth of water-worn debris. The grass does not dry up or burn like other grasses and a fire does little damage to it (Bor, *Kew Bull.*, 1952, 209).

The grass serves as a fodder, but is coarse and not much relished by cattle. It is eaten by wild animals in Assam and also used by wood-cutters and ranchers for feeding cattle. Analysis of grass cut at the prime stage gave the following values (dry basis): crude protein, 6.04; ether extr., 1.80; N-free extr., 44.95; crude fibre, 37.50; ash, 9.71; calcium, 0.32; and phosphorus, 0.12%; *digestibility co-efficients* (av.): crude protein, 44; ether extr., 51; crude fibre, 52; and N-free extr., 57%; starch equiv., 11.8 lb./100 lb. of green grass. Feeding trials on adult bullocks showed that the grass, at the prime stage, provided a maintenance ration when fed as a single feed; calcium and phosphorus balances were positive. Roughage consumption was, however, low (Talapatra, *Indian J. vet. Sci.*, 1950, **20**, 241).

M. vagans (Nees ex Steud.) A. Camus (syn. *Pollinia vagans* Nees ex Steud.; *P. grata* Hack.; *M. gratum* A. Camus), a perennial grass, 90–150 cm. high, with stout stems, sessile, linear leaves and densely fascicled spikes is found in Nepal, Sikkim, Himalayas

and Khasi and Mishmi hills up to a height of 1,500 m. It is considered to be a satisfactory fodder in Malaya. *M. nudum* (Trin.) A. Camus (syn. *Pollinia nuda* Trin.) is a slender grass with lanceolate leaves and slender spikes found in temperate Himalayas from Kashmir eastwards to Sikkim, at altitudes of 1,500–2,300 m., and in Khasi hills (Assam) and Palni hills (Madras). It is used as fodder (Bor, *Kew Bull.*, 1952, 209; Burkill, II, 1786).

MICROTOENA Prain (*Labiatae*)

A small genus of perennial herbs distributed in India, Java and China. Two species occur in India.

M. insuavis (Hance) Prain ex Dunn syn. *M. cymosa* Prain; *Plectranthus patchouli* C.B. Clarke.

D.E.P., VI(1), 308; C.P., 904; Fl. Br. Ind., IV, 624; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 185.

An erect herb, 40–100 cm. high, found in Tripura, Assam, Manipur and Khasi and Naga hills. Leaves long petioled, broadly ovate, acute, crenate-dentate; flowers yellow, in lax cymes; nutlets elliptic.

M. insuavis, known as patchouli of Assam or Khasia, smells strongly of patchouli obtained from *Pogostemon* sp. and may prove to be of commercial importance. It is said to be used to adulterate *Pogostemon heyneanus* Benth. (Bombay Patchouli) (Dummond, *Perfum. essent. Oil Rec.*, 1960, **51**, 484).

MIKANIA Willd. (*Compositae*)

A large genus of scandent herbs or shrubs distributed in tropical America, Africa and Asia. One species occurs in India.

M. cordata (Burm.) B. L. Robinson syn. *M. scandens* Hook. f. (Fl. Br. Ind.), non Willd.

Fl. Br. Ind., III, 244; Koster, *Blumea*, 1934–35, **1**, 504.

A herbaceous climber found as a weed in West Bengal, eastern Assam, Aka hills and probably S. India. Leaves deltoid-ovate, cordate-ovate, entire or more or less coarsely crenate or undulate; heads four-flowered in compound corymbs: corolla dirty white or white; achenes linear-oblong with reddish pappus.

M. cordata is a noxious weed in tea gardens, sal and other timber forests and waste lands in West Bengal and Assam. It is reported to be an alternative host to the tea mosquito (*Helopeltis theivora* Waterh.). Eradication of the weed by uprooting and

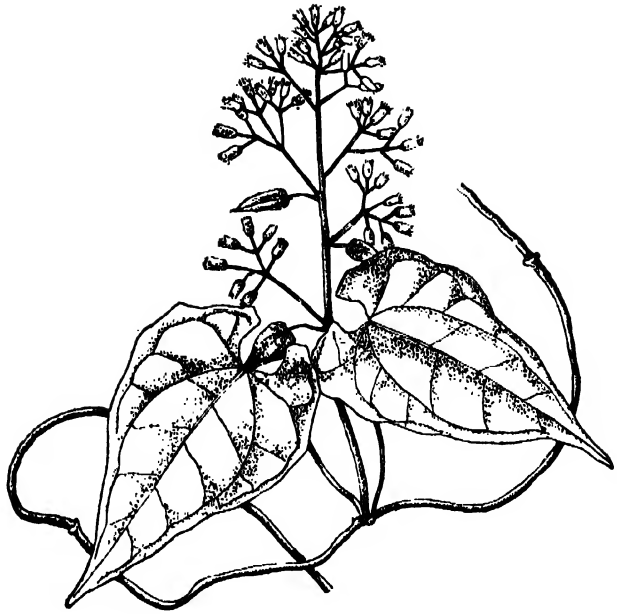


FIG. 138. MIKANIA CORDATA– FLOWERING BRANCH

burning is expensive. Weed killers, like 2, 4 D (Fernoxone, Chloroxone, etc.) are effective in controlling the weed, but their use in tea growing areas is not recommended as they cause damage to tea. Weed killers, like sodium arsenite and sodium chlorate, also cannot be used in tea areas. They can be applied only in waste lands and boundary areas, for controlling the weed and preventing its spread [Macalpine, *Two & A Bud*, 1959, **6**(1), 6; Chaudhuri, *Indian For.*, 1959, **85**, 562].

Because of its vigorous growth, *M. cordata* has been tried, in Malaya, for smothering weeds in young coconut plantations; it is considered useful for preventing soil erosion. Stems and leaves are relished by cattle, especially when fodder is scarce. Analysis of green material (from Malaya) gave the following values: moisture, 90.9; protein, 1.5; fat, 0.3; carbohydrates, 4.1; fibre, 2.1; ash, 1.1; calcium (CaO), 0.12; and phosphorus (P_2O_5), 0.08%; *digestible nutrients*: protein, 1.1; fat, 0.2; carbohydrates, 3.3; and fibre, 1.2%; nutritive ratio, 4.5; starch equiv., 5.9 lb./100 lb. It is a rich source of vitamins A and C; it contains also vitamin B. Leaves are used in some parts of Africa as a soup vegetable. They are used in Malaya for itches and in Java and S. Africa, for poulticing wounds (Burkill, II, 1470; Dalziel, 419; *Jt Publ. imp. agric. Bur.*, No. 10, 1947, 122; Teik, *Sci. Ser. Dep. Agric., Malaya*, No. 24, 1951, 69, 77, 83).

MILIUM Linn. (*Gramineae*)

D.E.P., III, 436; Fl. Br. Ind., VII, 235.

A small genus of annual or perennial grasses found in the north temperate regions of the world. One species occurs in India.

M. effusum Linn. (MILLET GRASS) is a slender perennial grass found in the mesophytic forests of western Himalayas from Kashmir to Kumaon at 1,800–3,300 m. Stems erect, tufted, 60–80 cm. high; leaves minutely scaberulous or smooth, 15–30 cm. long × 0.4–1.2 cm. broad; panicles 12.5–25.0 cm. long, with drooping branches.

The grass is occasionally cultivated for ornament; it is relished by cattle. The seeds provide food for game birds. Analysis of grass (from Kashmir) gave the following values (dry basis): protein, 17.82; ether extr., 2.95; carbohydrates, 37.43; crude fibre, 29.33; mineral matter, 10.97; calcium (as CaO), 1.08; and phosphorus (as P_2O_5), 0.41%. The plant contains coumarin (Bailey, 1947, II, 2050; Hubbard, 251; Chopra *et al.*, *Indian J. agric. Sci.*, 1956, **26,** 415; Wehmer, I, 80).

MILIUSA Lesch. (*Annonaceae*)

A genus of trees or shrubs distributed from South-East Asia to Australia. About a dozen species are found in India.

M. tomentosa (Roxb.) J. Sinclair syn. *Saccopetalum tomentosum* Hook. f. & Thoms.

D.E.P., VI (2), 381; C.P., 95; Fl. Br. Ind., I, 88; King, *Ann. R. bot. Gdn Calcutta*, 1893, **4,** 159, Pl. 207.

HINDI—*Kari, kirua*; MAR. & GUJ.—*Hoom, humba*; TEL.—*Chilkadudu*; TAM.—*Periuvay*; KAN.—*Hessare, wumb*; ORIYA—*Patmossu, gandhapalsa.*

A moderate-sized to large deciduous tree found from the sub-Himalayan tracts of U.P. and Nepal Terai southwards throughout the greater part of India. Bark brown, fissured; leaves ovate-oblong, membranous, faintly aromatic; flowers in few-flowered cymes; fruit purple or black, consisting of sub-globose, succulent carpels.

The tree occurs occasionally in association with sal. It coppices well. The wood is olive-yellow to brown, without distinct heartwood, smooth, close-grained, moderately hard and heavy (wt., 40 lb./cu. ft.); it presents a well-marked silver grain in the radial section. It is fairly durable; graveyard tests indicate a durability of 2–5 years. It takes a smooth surface from the tool. The wood is used mostly for

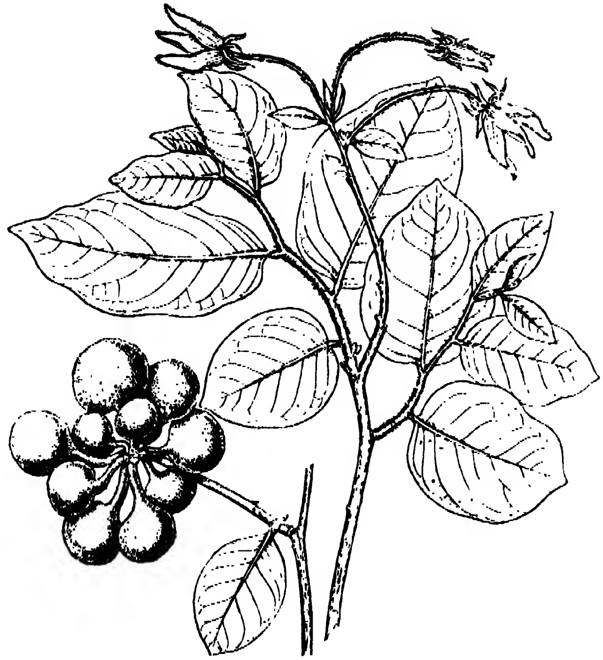


FIG. 139. MILIUSA TOMENTOSA—FLOWERING AND FRUITING BRANCHES

building huts and cattle sheds. It is suitable for cabinet work, carving, slack cooperage, bobbins, picker arms, shuttles and billiard cues. It is a good fuel wood (calorific value of *sapwood*—5,578 cal., 10,040 B.t.u.). Destructive distillation of wood gave the following products (dry basis): charcoal, 36.1; total distillate, 41.1; pyroligneous acid (dry), 32.7; acid (as acetic), 4.22; esters, 3.40; acetone, 2.12; methanol, 1.08; tar, 8.3; and pitch & losses, 5.4%; and gas (at N.T.P.), 1.74 cu. ft./lb. (Troup, I, 9; Gamble, 22; Howard, 521; Purushotham *et al.*, *Indian For.*, 1953, **79,** 49; Trotter, 1944, 198, 207, 218, 224, 225; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 23; Kedare & Tendolkar, *J. sci. industr. Res.*, 1953, **12B,** 217).

The fruit is said to be eaten in some parts of Bombay. The leaves are often lopped for fodder. The tree yields a pale yellow gum, known as *karee* gum, used as a substitute for tragacanth (Howes, 1949, 78).

M. velutina Hook. f. & Thoms.

D.E.P., V, 245; Fl. Br. Ind., I, 87; King, *Ann. R. bot. Gdn Calcutta*, 1893, **4,** 158, Pl. 206.

HINDI—*Dom-sal, kari, gidar rukh*; TEL.—*Pedda-chilka duduga, nalla duduga*; MAL.—*Kana kaitha, vilumi*; ORIYA—*Gandha palas.*

BIHAR—*Ome*; GARO—*Bor samphol.*

A small to medium-sized deciduous tree found in the sub-Himalayan tract and outer Himalayas from Jamuna eastwards, up to an altitude of 900 m., and in north-east and Central India, eastern coast of Deccan Peninsula and Travancore. Bark dark greyish brown, rough; leaves ovate-elliptic or oblong, coriaceous, aromatic; flowers in cymes, greenish yellow; fruit purple or black, consisting of rounded succulent carpels.

The tree occurs frequently in sal forests; it comes up in small blanks containing coarse grasses and thus forms a natural nurse for the regeneration of sal. It is a moderate shade bearer, somewhat frost-tender but drought hardy. It coppices well and also reproduces from root suckers. The rate of growth is slow (Troup, I, 8–9).

The wood is yellow when first exposed, turning greyish brown, without distinct heartwood; somewhat lustrous, especially on the radial face, with smooth feel, straight- and close-grained, even and medium fine-textured; moderately hard, strong, elastic and heavy (sp. gr., *c.* 0.78; wt., 46–53 lb./cu.ft.) (Pearson & Brown, I, 28–29).

The timber is difficult to season and is liable to warping and end-splitting; green conversion and open stacking under cover are recommended. The timber is not durable: graveyard tests indicate a life up to 23 months. It is easy to work and saw, machines well, lends itself to turnery and finishes to a good surface. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 110; strength as a beam, 70; stiffness as a beam, 70; suitability as a post, 70; shock-resisting ability, 90; retention of shape, 65; shear, 140; and hardness, 105 (Pearson & Brown, I, 29; Purushotham *et al.*, loc. cit.; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, Sheet No. 14).

The wood is used for building, flooring, ceiling planks, furniture, agricultural implements, yokes and carts, tool handles, shafts, axles, oars, packing cases and gunstock. It is reported to be suitable for match boxes (Pearson & Brown, I, 29; Rodger, 50; Rama Rao, 9).

The fruit of the tree is eaten. The leaves provide fodder of medium quality. The stem yields a fibre locally used for tying purposes. The bark is said to possess purgative properties (Laurie, *Indian For. Leafl.*, No. 82, 1945, 9; Trotter, 1940, 233; Burkill, II, 1470).

M. roxburghiana Hook. f. & Thoms. (LEPCHA—*Sungden-kung*; ASSAM—*Chhag-loti, tasemayang-changne*) is a small tree found in eastern Himalayas and Assam hills up to an altitude of 1,200 m. The wood is greyish white, hard and heavy (wt., 51 lb./cu. ft.). It is suitable for agricultural implements and constructions of a temporary character (Gamble, 21; Fl. Assam, I, 42).

Milk Bush — *see* **Euphorbia**

Millet, African — *see* **Eleusine**

Millet, Barnyard — *see* **Echinochloa**

Millet, Common — *see* **Panicum**

Millet, Cumboo — *see* **Pennisetum**

Millet, Finger — *see* **Eleusine**

Millet, Great — *see* **Sorghum**

Millet, Indian — *see* **Sorghum**

Millet, Italian — *see* **Setaria**

Millet, Little — *see* **Panicum**

Millet, Spiked — *see* **Pennisetum**

MILLETTIA Wight & Arn. (*Leguminosae*)

A genus of trees and shrubs distributed throughout the warmer parts of the world. About a dozen species are found in India; a few exotics are cultivated in gardens.

M. extensa Benth. ex Baker syn. *M. auriculata* Baker ex Brandis

D.E.P., V, 247; Fl. Br. Ind., II, 109.

HINDI—*Gauj, gonj*; TEL.—*Kondatangedutige*; MAL.—*Valli muritali*; ORIYA—*Arkawla, kissi, rekorlo.*

A sub-erect shrub, more often a woody climber, up to 20 m. in length and 25 cm. in diam., found throughout the sub-Himalayan tract and outer Himalayas up to an altitude of 1,200 m. and in Assam, extending southwards to Godavari; it has been recorded also from some parts of South India. It is common in sal forests and is often an obnoxious weed. Bark yellowish brown with small rough lenticels; leaves imparipinnate: leaflets obovate, oblong to elliptic; flowers in axillary racemes, whitish or brownish; pods strap-shaped, hard.

The leaves and twigs of the plant are lopped for cattle fodder; they are eaten by elephants. The leaves are fairly rich in protein, calcium and phosphorus; analysis of leaves (from Izatnagar) gave the following values (dry matter basis): crude protein, 22.68; ether extr., 4.57; N-free extr., 30.93; crude

fibre, 32.50; ash, 9.32; calcium, 1.92; and phosphorus, 0.29%: digestible crude protein, 15.54; total digestible nutrients, 44.88%; and nutritive ratio, 1.89. Feeding trials with Kumaoni bullocks showed positive balances for nitrogen, calcium and phosphorus. The leaves can be profitably fed in combination with dry roughages, such as straw and hay, which are poor in digestible protein (Jayal & Sahai, *Indian J. Dairy Sci.*, 1960, **13,** 77; Gamble, 233).

The root is reported to possess insect-repellent properties. It is used as fish poison and also applied to sores of cattle to kill vermin: an infusion of powdered roots is rubbed on cattle and horses to keep off flies (Chopra *et al.*, 58, 392; Witt, 64).

The bark and stem yield a coarse fibre used as rough cordage; they are beaten and used as brushes (Gamble, 233; Trotter, 1940, 231).

M. pachycarpa Benth.; Baker (Fl. Br. Ind.) in part
Fl. Br. Ind., II, 106.

Beng.—*Bishloti.*

Nepal. *Kurkus*; Assam—*Bokoa-bih, bokol-bih.*

A large climber found in eastern Himalayas and hills of Assam up to an altitude of 1,200 m. Leaves imparipinnate: leaflets oblanceolate: flowers in copious panicles, light mauve; pod woody, rugose, often indented between seeds; seeds 1–3.

The seeds and roots of *M. pachycarpa* are used locally for poisoning fish and birds. They possess considerable insecticidal activity, and in this respect they are similar to *Derris* and various species of *Lonchocarpus*. The seeds are more toxic than roots. The toxicity is due to the presence of rotenone and related compounds. Analysis of air-dried roots from Kalimpong (Bengal) showed that they contained 1.2% rotenone and 4.0% ether soluble extractives: two samples from Assam contained 0.9 and 2.8% rotenone and 1.6 and 4.3% ether extractives. The roots also contain dehydrorotenone. Roots up to 2.5 cm. diam. are richer in rotenone than thicker roots, and the total yield of rotenone-rich roots has been estimated at 2 lb. per plant, which is much more than the yield of roots from *Derris* plants. Analysis of seeds of *M. pachycarpa* gave the following values: moisture, 11.0; ether extr., 12.0; chloroform extr., 17.0; and rotenone and deguelin, 0.65%; the seeds also contain a saponin ($C_{32}H_{54}O_{18}$) and are rich in fixed oil and carbohydrates. Extracts and aqueous suspension of finely ground seeds are effective when used in sprays against a variety of insects, like houseflies, bean aphids, pentatomids, leaf beetles and cabbage worms. They act both as stomach and contact poisons; they are also ovicidal. The residual toxicity of ether extracts of the seeds when used in high initial concentrations, lasts for a few days after spraying; at low concentrations, no residual toxicity is observed. Ground seeds deteriorate in toxicity when exposed to sunlight or to a temperature of 98°F. Toxicity tests against fourth instar silkworm showed that the seeds of *M. pachycarpa* are 1/8 as toxic as rotenone or nearly as toxic as arsenic pentoxide. The seeds are easy to harvest and the plant deserves further study especially from the point of view of plant selection and breeding for higher potency (Trotter, 1940, 300; Ghose, *Indian For. Leafl.*, No. 20, 1942, 6; Rao, *J. sci. industr. Res.*, 1954, **13A,** 31; Chiu, *J. Sci. Fd Agric.*, 1950, **1,** 276; Spickett, *Colon. Pl. Anim. Prod.*, 1955, **5,** 288; Chiu *et al.*, *J. econ. Ent.*, 1942, **35,** 80; Tattersfield *et al.*, *Kew Bull.*, 1948, 329; Mukerjea & Tripathi, *J. sci. industr. Res.*, 1956, **15C,** 106).

M. leucantha Kurz syn. *M. pendula* Benth. ex Baker is a tree found in Burma; it is grown in the Forest Research Institute, Dehra Dun. The wood is brown, straight- or interlocked-grained, and medium to coarse-textured; it is strong, hard, heavy (sp. gr., 0.95–1.03; wt., 64 lb./cu. ft.) and durable. It is used in Burma for house posts, bridges, ornamental furniture, panels, brush backs, cabinet making, carving, turnery, etc. (Pearson & Brown, I, 350–52; Rodger, 132, 134–35).

M. ovalifolia Kurz is a handsome tree grown in gardens for its elegant foliage and handsome racemes of lilac or mauve flowers (Benthall, 145).

M. piscidia Wight (Khasi—*Dieng-sohlynthein*) is a woody climber or a small tree with greyish brown bark and white flowers found in Sikkim and Assam hills. The bark and flowers are used as fish poison (C.P., 546).

M. pulchra Benth. ex Baker (Khasi—*Dieng-shakuriao, dieng-tiw-khmat, taw-tynneng, sa-long-teu*) is an erect shrub or a small tree, up to 9 m. in height, found in the hills of Assam and in Manipur. The wood is tough and suitable for tool handles and agricultural implements (Fl. Assam, II, 26).

M. racemosa Benth. (Hindi—*Jungi*; Tel.—*Galuga*) is a woody climber found in the Deccan Peninsula. Like *M. extensa* it is also a forest weed. The leaves are used as fodder. The root is used as fish poison; it is applied to sores on cattle to kill vermin (Troup, I, 250; Haines, III, 246).

MILLINGTONIA Linn. f. (*Bignoniaceae*)

A monotypic genus of trees native of Burma and Malaya. *M. hortensis* has become naturalized in India.

M. hortensis Linn. f. INDIAN CORK TREE

D.E.P., V, 247; Fl. Br. Ind., IV, 377; Blatter, *et al.*, 106, Pl. XXII.

HINDI—*Neem-chameli, akas nim, mini-chambeli;* BENG.—*Cork-gach, akas nim, mini-chambeli;* MAR.—*Akas-nimb, kavala-nimb, nimi-chambeli;* TEL.—*Kavuki;* TAM.—*Mara-malli;* KAN.—*Beratu;* MAL.—*Katesam;* ORIYA—*Bakeni, reali, mach-mach, sitahara.*

A tall tree, up to 24 m. in height, with a straight trunk and an elongated pyramidal crown with deep green foliage, cultivated throughout India for ornament. Bark yellowish grey, rough, corky; leaves 2–3 pinnate: leaflets oval to ovate-lanceolate; flowers in terminal panicles, white or pinkish, fragrant: capsules slender, compressed; seeds many, flat, winged.

The tree is hardy. It grows best in a moist climate, but does fairly well in dry situations also. In some areas it seldom produces seed. Propagation may be done by sowing seeds soon after they become available at the end of the hot season and transplanting seedlings about a year later, at the beginning of rains. The tree can be raised from cuttings planted in spring or by root suckers transplanted during the rainy season. The growth is fast, the recorded mean annual girth increment being 1.26–1.57 in. The tree coppices fairly well and underground portions retain vitality for years after the tree has been cut (Troup, II, 692–93; Cameron, 205).

The tree is chiefly grown for its stately form, handsome foliage and profusion of attractive fragrant flowers which appear from September to December. It is grown also as an avenue tree, but it gives little shade and being brittle and shallow rooted, it is liable to be broken or uprooted by strong winds. It has a tendency to send up root suckers in abundance which is a disadvantage in gardens (Firminger, 412; Troup, II, 693; Blatter *et al.*, 106–08; Benthall, 334).

The wood is yellowish white, soft, moderately heavy (wt., 42 lb./cu.ft.), close- and even-grained. Green conversion and careful seasoning yield fairly durable timber. It is suitable for furniture, ornamental work, tea boxes, drawing boards and plane tables. The bark yields an inferior type of cork. It contains a bitter substance and some tannin, and is reported to be used in Indonesia as an antipyretic (Gamble, 510; Cameron, 205; Trotter, 1944, 214; Wehmer, II, 1133).

MILLIPEDES AND CENTIPEDES (Phylum *Arthropoda*, classes *Diplopoda* and *Chilopoda*)

Millipedes (Class *Diplopoda*) and centipedes (Class *Chilopoda*) are characteristically terrestrial, vermiform animals with a distinct head, one pair of feelers and a long segmented body, inhabiting damp and dark places and avoiding light. They have a worldwide distribution. The diplopod and chilopod fauna of India have been only partially explored. About 115 species of the former, belonging to some 50 genera have been recorded from different parts of the country; the well-known Indian species of chilopods belong to the genus *Scolopendra* (Linn.) Newport.

The millipedes are among the most ancient of the terrestrial arthropoda. They vary considerably in size, from *c.* 2 mm. to 200 mm. The body is more or less cylindrical; each trunk segment after the fourth, bears 2 pairs of legs; poison claws are absent. In centipedes, the body is flattened and each of the trunk segments, excepting the first, bears a single pair of legs. The appendages of the first segment are modified into a pair of claws with perforated tips through which poisonous secretion is injected into the prey.

Among the species of millipedes recorded in India, the common ones are: *Arthrosphaera heterosticta* (Newport), *A. magna* Attems, *Zephronia nigrinota* Butler, *Z. alticola* Attems, *Chondromorpha severini* Silvestri, *C. mammifera* Attems, *Streptogonopus phipsoni* (Pocock) and *Trigoniulus lumbricinus* (Gerst.). The millipedes feed exclusively on plant material. Some species are known to injure agricultural crops, but their masticatory organs are weak and they can damage only delicate tissues or structures exposed by other pests. They aid in the breakdown of humus in the soil. The repugnatorial fluid of some large tropical species has a strong caustic action, blackening human skin on contact; affected skin peels off leaving a slowly healing wound. The fluid is injurious to eyes and numerous cases of blindness among chickens are attributed to it (Pocock, *J. Bombay nat. Hist. Soc.*, 1899, **12,** 269–85, 465–74; Bhatia, ibid., 1927–28, **32,** 382–84; Hingston, ibid., 1930–31, **34,** 404–10; Attems, *Mem. Indian Mus.*, 1936, **11,** 133–323; Thomson, 389–93; Pycraft, 191–94; Buchsbaum, 272–74; Cloudsley-Thompson, 15–40).

Scolopendra spp. are notorious for their poisonous and painful bites. The bite of *S. subspinipes* Leach, found throughout India, produces intense pain, blistering, swelling, local inflammation, bubos and subcutaneous haemorrhage. *S. morsitans* (Linn.), also found throughout India and Andaman Islands, is said to be as venomous as a scorpion and its bite causes considerable swelling. The poison of *S. cingulata* Latr. causes oedema and great pain and discomfort. Cases of accidental pseudoparasitism by centipedes in human beings have been recorded.

Centipedes are reported to be eaten by some people in India. In Thailand, some species are roasted and given to sickly children with swollen bellies; they are also employed in the preparation of a stimulant mixture (Pocock, *J. Bombay nat. Hist. Soc.*, 1892, **7,** 131–74; Gravely, *Rec. Indian Mus.*, 1910, **5,** 157–59, 161–72; Bayley-De Castro, *J. Bombay nat. Hist. Soc.*, 1927–28 **32,** 232–34; Pycraft, 191–94; Buchsbaum, 272–74; Cloudsley-Thompson, 40–58).

MIMOSA Linn. (*Leguminosae*)

A large genus of thorny and woody plants, mostly natives of tropical and sub-tropical America; a few species have been recorded in Africa and Australia. About seven species occur in India.

FIG. 140. MIMOSA HAMATA—FLOWERING AND FRUITING BRANCH

M. hamata Willd.

Fl. Br. Ind., II, 291.

TEL.—*Undra*; TAM.—*Indiri*.

BOMBAY—*Aukur*; BERAR—*Chilathi*.

A much-branched prickly shrub found in the plains of Punjab, Central and South India. Leaves small, bipinnate; flowers red, in globose heads; pods 4.0–5.0 cm. long, flat, curved, prickly at edges.

The plant can be grown as a hedge plant. It flowers during July–September and fruits from November to January. Analysis of the plant gave the following values (dry wt. basis): nitrogen, 2.73; phosphorus (P_2O_5), 0.28; potash (K_2O), 1.01; and calcium (CaO), 4.02%; it may be tried for green manuring purposes. The plant is browsed by cattle; dried leaves of the plant contain: ether extr., 7.88; albuminoids, 11.87; carbohydrates, 58.34; fibre, 12.12; and ash, 9.85% (Idnani & Chibber, *Sci. & Cult.*, 1952–53, **18,** 362; Lander, *Misc. Bull. Indian Coun. agric. Res.*, No. 16, 1942, 84).

M. himalayana Gamble* syn. *M. rubicaulis* Baker (Fl. Br. Ind.) in part, non Lam.

D.E.P., V, 248; Fl. Br. Ind., II, 291 (in part); Kirt. & Basu, Pl. 373A.

HINDI & BENG.—*Shiah-kanta*; TEL.—*Kodimudusu, undra, ventra.*

ASSAM—*Kuchoi-kaitkusia-kant, kauri-kanta*; GARO—*Remsum*; MIKIR—*Ingsu-maha*; PUNJAB—*Deo-khadia*; KUMAON—*Khinkari*; BIHAR—*Khirlachi kanta.*

An erect or straggling shrub, 1.5–3.0 m. high, with smooth bark and thorny branches found throughout India ascending to 1,000 m. in the outer Himalayas. It is common along open water courses, heavily grazed scrub forests and abandoned cultivated lands; it is considered useful for hedges. It yields a

* Gamble (*Kew Bull.*, 1920, 1) considers the plant occurring in the region south of Godavari as *M. rubicaulis* Lam. syn. *M. rubicaulis* Baker (Fl. Br. Ind.) in part. The name *M. himalayana* is assigned to the plant occurring in the Himalayas from Afghanistan in the west to Mishmi hills in the east, extending to Assam valley, Khasia hills and Sylhet southwards to Godavari.

red heartwood (wt., 41–52 lb./cu.ft.) which is fairly hard and close grained and suitable for use as tent pegs and for making gunpowder charcoal. The root, leaves and fruits find minor medicinal uses (Gamble, 290 ; Osmaston, 194 ; Haines, II, 323 ; Kirt. & Basu, II, 918).

M. pudica Linn. SENSITIVE PLANT

D.E.P., V, 248 ; Fl. Br. Ind., II, 291 ; Kirt. & Basu, Pl. 373B.

HINDI—*Lajwanti, chui-mui* ; BENG.—*Lajjabati* ; MAR.—*Lajalu* ; TEL.—*Attapatti, peddanidrakanni* ; TAM.—*Tottalvadi, thottal-chinungi* ; KAN.—*Lajja, nachike, mudugu-davare* ; MAL.—*Tintarmani* ; ORIYA—*Lajkuri*.

ASSAM—*Nilajban, adoriban* ; KHASI—*Kambatsamthia, sunteshuh* ; MUNDARI—*Durum-junum*.

A diffuse undershrub, 50–90 cm. high, native of tropical America, naturalized nearly throughout the tropical and sub-tropical parts of India. Stem and rachis clothed with prickles ; leaves bipinnate : pinnae 2–4, digitatively arranged, with 10–20 pairs of leaflets ; flowers in pinkish globose heads ; pods small, flat, straw-coloured, with many bristles ; seeds 3–5.

This species is highly polymorphic and includes three varieties, viz. var. *hispida* Brenan, var. *tetrandra* DC. and var. *unijuga* Griseb. It is common in waste ground, particularly where the climate is warm and moist, and is exceedingly sensitive to touch. In many places, it has become a troublesome weed. Application of MCPA at 4–6 lb. per acre affords effective control [Brenan, *Kew Bull.*, 1955, 161 ; Use of Leguminous Plants, 226 ; Ram Gopal, *Indian Fmg, N.S.*, 1954–55, **4**(10), 23].

The tender plant is readily eaten by cattle. It is said to be used as pasture in Fiji. It stands heavy grazing and is reported to produce firm flesh and increased flow of milk when fed to cattle. Analysis of flowering tops (from Fiji) gave the following values: moisture, 74.9 ; protein, 5.5 ; carbohydrates, 9.0 ; fat, 0.8 ; fibre, 8.2 ; and ash, 1.6%. Trials in Ceylon showed that the presence of *M. pudica* in grassland improved the value of pasture for cattle. The plant becomes thorny when it grows old and should be kept in order by grazing and occasional burning. Consumption of pods is likely to cause intestinal inflammation in cattle. Feeding trials with horses indicated that the plant causes toxic symptoms ; in large doses, loss of hair has been observed. When fed to chicks, the leaf meal caused stunted growth and bloating ; the birds become sickly and may die in a few weeks. The plant has been tried as green manure [Turbet & Thuraisingham, *Trop. Agriculturist*, 1948, **104**, 81 ; Burkill, II, 1474 ; Henry, 4 ; Gapuz *et al.*, *Araneta J. Agric.*, 1957, **4**(3), 78 ; Use of Leguminous Plants, 226 ; Whyte *et al.*, 301].

M. pudica contains a toxic alkaloid, mimosine ($C_8H_{10}O_4N_2$, m.p. 226–27°), identical with leucenine from *Leucaena glauca* (q.v.). Leaves, stems and roots give positive tests for alkaloids, but the total quantity present is small. An adrenaline-like substance has been identified in the extracts of leaves ; perfusion of mimosa ground in Ringer's solution showed adrenaline action on isolated frog heart. Crocetin dimethyl ester is present in the pulvini of the plant. The roots contain tannin (*c.* 10%) (Manske & Holmes, I, 211 ; Heilbron & Bunbury, III, 175 ; Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 268, 1952, 54 ; *Chem. Abstr.*, 1950, **44**, 2180 ; 1948, **42**, 3812 ; 1949, **43**, 3475 ; Banerji *et al.*, *Trans. Bose Res. Inst.*, 1946, **16**, 155).

The seeds of the plant contain a mucilage composed of *d*-xylose and *d*-glucuronic acid. They yield 17% of a greenish yellow, fatty oil, with the following characteristics: sp. gr.$^{40°}$, 0.9195 ; $n^{40°}$, 36 cs. ; $n^{30°}$, 1.4691 ; acid val., 4.0 ; sap. val., 191.2 ; iod. val. (Wijs), 130.6 ; thiocyanogen val., 74.0 ; Hehner val., 95.0 ; acet. val., 21.8 ; hexabromide val., nil ; R.M. val., 0.17 ; and unsapon. matter (sitosterol and a sterol), 2.5%. The component fatty acids of the oil are: palmitic, 8.7 ; stearic, 8.90 ; oleic, 31.0 ; linoleic, 51.0 ; and linolenic, 0.4%. The oil resembles soybean oil and may find similar uses. Owing to its high linoleic and low linolenic acid content, it may be suitable for dimerization and production of coating materials, such as Norelac (Hulyalkar *et al.*, *J. Indian chem. Soc.*, 1956, **33**, 864 ; Aggarwal & Karimullah, *J. sci. industr. Res.*, 1945–46, **4**, 80).

A decoction of the root of the plant is considered useful in gravel and other urinary complaints. A paste of the leaves is applied to glandular swellings ; the juice of leaves is used in dressings for sinus and also as an application for sores and piles (Kirt. & Basu, II, 915 ; Nadkarni, I, 799).

M. invisa Mart., a climbing shrub with pubescent stems armed with recurved prickles, has been introduced into India and tried as a green manure crop in coffee estates. It is grown in Indonesia and Indo-China as a green manure or cover plant. In Ceylon, it is regarded as a potentially serious weed. The plant dries up under heavy shade and during dry weather ; it is also difficult to handle due to its thorny nature. A thornless strain of this species has been isolated

in Java and is expected to become popular particularly because it suppresses the growth of *Imperata cylindrica*. *M. sepiaria* Benth. is a small prickly shrub commonly occurring in India. It is useful for hedges and as fuelwood (Use of Leguminous Plants, 224; *Annu. Rep. Res. Dep. Coffee Bd, India*, 1954–55, 47; Manual of Green Manuring, 122; Toxopeus, *Euphytica*, 1952, **1**, 130).

MIMULUS Linn. (*Scrophulariaceae*)

Fl. Br. Ind., IV, 258; Bailey, 1949, 897.

A large genus of annual or perennial herbs or rarely shrubs distributed mostly in temperate America, and a few in the Old World. Three species occur in India and a few exotics are grown in gardens for their brilliantly coloured flowers (Gopalaswamiengar, 446).

M. moschatus Dougl. (MUSK PLANT) is a perennial herb, native of America, with oblong-ovate leaves and pale yellow flowers found growing in some south Indian hill stations. The plant is reported to be used as a substitute for musk and possesses stimulant properties. Though considered non-toxic, a case of poisoning of sheep due to it has been suspected in New Zealand (Firminger, 422; Connor, *Bull. Dep. sci. industr. Res. N. Z.*, No. 99, 1951, 101; Hocking, 141; Wehmer, II, 1121).

M. strictus Benth. syn. *M. gracilis* Hook. f. (Fl. Br. Ind.), non R. Br. is a perennial ascending or decumbent herb with linear-oblong or oblong-lanceolate leaves and white, pale blue or pinkish flowers found along streams, moist, shady places and banks of rice fields in the plains of North India ascending up to 900 m. from Kashmir to North Bengal and in the Deccan. The plant is reported to be used as remedy in menstrual disorders (Watt & Breyer-Brandwijk, 170).

MIMUSOPS Linn. (*Sapotaceae*)

A genus of trees distributed in the tropics of the Old World. One species is found in India.

M. elengi Linn.

D.E.P., V, 249; C.P., 627, 821; Fl. Br. Ind., III, 548.

HINDI—*Maulsari*; BENG.—*Bakul*; MAR.—*Ovalli*; GUJ.—*Barsoli*, *bolsari*; TEL.—*Pogada*; TAM.—*Vagulam*, *magadam*, *ilanji*; KAN.—*Bakula*, *pagade*; MAL.—*Elengi*, *ilanni*; ORIYA—*Bokulo baula*.

ASSAM—*Gokul*.

TRADE—*Bulletwood*.

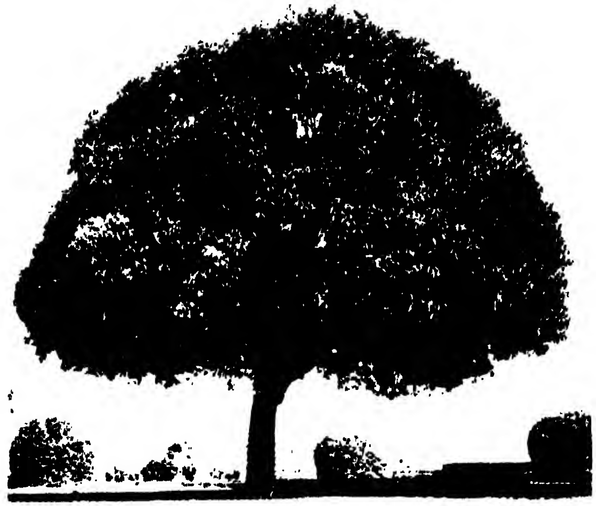


FIG. 141. MIMUSOPS ELENGI

A small to large evergreen tree found in the Deccan Peninsula and Andaman Islands, and frequently cultivated in gardens for ornament; it is grown also as an avenue or shade tree throughout the greater part of India. Bark dark grey, fissured; leaves variable, elliptic, oblong or oblanceolate; flowers axillary, solitary or in fascicles, small, creamy white, star-shaped, fragrant; berry ovoid, containing 1, rarely 2 seeds, yellow when ripe: seeds ovoid, compressed, greyish brown, shining.

The tree attains large dimensions in the moist evergreen forests of western ghats; in the eastern ghats, it is found in dry areas, often on laterite, and is comparatively small in size. In Andamans it attains a height up to 35 m. with a bole c. 6 m. long × 2.5 m. girth. The tree is a shade bearer and appears to reproduce well under shade. It is best propagated by sowing seeds singly in baskets and planting out seedlings in the field, usually after two years, in the rainy season. The rate of growth is slow (Troup, II, 637–38).

The tree is susceptible to the attack of a wound fungus, *Fomes senex* Nees & Mont., which affects the wood: the heartwood is ultimately destroyed and affected trees are liable to wind throw. *Arrhenothrips ramakrishnae* Hood causes leaf gall formation [Bagchee & Bakshi, *Indian For. Rec.*, *N.S.*, *Mycol.*, 1950, **1**(1), 6; Ananthakrishnan, *Agra Univ. J. Res.*, 1954, **3**, 463].

FIG. 142 MIMUSOPS ELENGI—FLOWERING AND FRUITING BRANCH

The sapwood is pale reddish to brownish white, sharply defined; heartwood deep red to dark reddish brown, often with darker lines, moderately ornamental; smooth, fairly straight- to shallowly interlocked-grained, even- and fine-textured, very hard, tough, strong and heavy (sp. gr., 0.80–1.02; wt., 49–62 lb./cu. ft.). The timber seasons well, though it shows a marked tendency to develop short, wavy surface cracks. It can be kiln-seasoned without degrade. The wood is durable; graveyard tests indicated a natural durability of 10–15 years. The wood is considerably more difficult to saw in the seasoned than in the green state. It works easily to a good surface and takes a beautiful polish. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 130; strength as a beam, 105; stiffness as a beam, 115; suitability as a post, 100; shock-resisting ability, 135; retention of shape, 65; shear, 150; and hardness, 160 (Pearson & Brown, II, 680, 682–83; Purushotham *et al.*, *Indian For.*, 1953, **79,** 49; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** 55, Sheet No. 14).

Bulletwood is used for building purposes, piles, bridges, boats, oars, masts, spars, agricultural implements, carts, rice pounders, crushers and oil mills. It is also used for furniture, cabinet work, panels, marline spikes, belaying pins, tools, turnery, picture frames, musical instruments and walking sticks. It has been recommended for wooden bearings [Pearson & Brown, II, 683; Burkill, II, 1477; Kapadia, *J. Gujarat Res. Soc.*, 1954, **16**(1), 15; Trotter, 1944, 195].

The caducous corollas of flowers which fall in showers from the tree are valued for making garlands and sometimes for stuffing pillows; they retain their fragrance long after drying. In Thailand, an infusion of the flowers is used as a cosmetic after bath. The flowers are also used in distilling an otto used in perfumes and as stimulant. Fresh flowers on water-distillation yield 0.01% of the otto having the following characteristics: sp. gr.^{35}, 0.9594; n^{28}, 1.4935; $[\alpha]$, +4.4°; acid val., 64.5; ester val., 154.0; sol. in 1 vol. of absolute alcohol (Gupta *et al.*, *Perfum. essent. Oil Rec.*, 1954, **45,** 80; Burkill, II, 1476).

The ripe fruit is edible; it is sometimes used for making preserves and pickles. The seed kernels yield 16–25% of a fatty oil, used for edible and lighting purposes. The crude oil has a reddish brown colour with an unpleasant odour and is more or less tasteless. The refined oil is almost colourless and odourless, but it acquires a yellow tint on exposure to air. The constants of the oil are: d_{28}^{28}, 0.9113; n_D^{30} 1.4655; acid val., 2.2; iod. val., 82.2; sap. val., 188.0; acet. val., 12.0; and unsapon. matter, 1.30%. The composition of the total fatty acids of the oil is as follows: palmitic, 10.97; stearic, 10.10; behenic, 0.46; oleic, 63.98; and linoleic, 14.49% (Eckey, 713; Kartha & Menon, *Proc. Indian Acad. Sci.*, 1944, **19A,** 1; Ran & Simonsen, *Indian For. Rec.*, 1922–23, **9,** 104).

Bassic acid ($C_{30}H_{46}O_5$, m.p. 319–24°), the characteristic sapogenin of *Sapotaceae*, has been isolated from the fat-free seed meal in a yield of 2.4%; a saponin, which on hydrolysis yields rhamnose (2 mol.), arabinose (2 mol.) and glucose (1 mol.), has also been reported. The bark contains 3–7% tannin; it is used in some parts of India for dyeing and tanning purposes. The bark and flowers are reported to contain a saponin and an alkaloid. The tree also yields a gum [*Chem. Abstr.*, 1940, **34,** 6636; 1930, **24,** 856; Heilbron & Bunbury, I, 234; Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 153; Wehmer, II, 940].

The tree is lopped for fodder; the fodder is of medium quality. Young twigs are used for cleaning teeth. The bark and fruit are astringent and tonic; they are used in diarrhoea and dysentery; a decoction of the bark is used as gargle. A snuff made from dried flowers induces copious defluxion from the nose and relieves headache and pains. Pounded seeds are pasted with oil or ghee and used in suppositories in case of obstinate constipation, especially for children (Laurie, *Indian For. Leafl.*, No. 82, 1945, 9; Bindal, 131; Chopra, 1958, 514; Kirt. & Basu, II, 1495; Nadkarni, I, 801; Burkill, II, 1476–77).

Mimusops spp. — *see* **Manilkara**

MINERAL SPRINGS

A large number of mineral springs or overflows from underground reservoirs of water, occur in India. Some of these are thermal or hot springs, and the Geological Survey of India recorded some 300 of these. Whether thermal or cold, waters of all mineral springs contain molecular quantities of salts in solution. They are used for baths and also taken internally as medicinal or table water. Some of them are believed to be efficacious in curing or ameliorating physical ailments. Directions for drinking and bathing, engraved on stones laid beside the thermal springs in Changrizand and in Spiti in the Himalayas, bear testimony to such belief. Several springs like Devaki Unai in Surat dist. (Gujarat), Sitakund in Monghyr dist. (Bihar), Bakreswar in Birbhum dist. (West Bengal) and others are popularly believed to have a divine origin. It is not surprising that several places of pilgrimage, e.g. Badrinath in Garhwal dist. and Jumnotri in Tehri, are located at the sites of hot springs.

In many countries, mineral springs have been commercialized both as spas and as sources of medicinal and table waters. In India, however, vested and religious interests and complications of private ownership have largely stood in the way of their commercialization. The Geological Survey of India undertook a systematic survey of the mineral springs of India during the early years of World War II with a view to examine their commercial potentialities; the survey was interrupted in 1941. In all, 112 springs were investigated, the largest number being in Bihar and Maharashtra, and a smaller number in West Bengal, Uttar Pradesh, Punjab and Madhya Pradesh. Other States were not covered by the survey. The survey has shown that majority of springs occur in broad belts following regional tectonic trends. In the coal-field region of Bihar, the springs occur parallel to the east-west boundaries of the coal areas which are defined by well marked faults. The springs of Monghyr dist. follow the strike of the quartzite ridge of Kharagpur hills trending from N.NE-S.SW to NE-SW. Similarly, the E.NE-W.SW trend of Rajgir springs parallel the strike of the ridge of quartzites. The linear distribution of these springs suggest planes of dislocation. The Bihar springs are situated in the Archaean terrain and have certain peculiarities of composition largely ascribed to the nature of the country rock.

The group of thermal springs in Ratnagiri, Thana and Kolaba districts of Maharashtra and in Surat dist. of Gujarat follow the north-south trend of the west coast of India, believed to be due to dislocations brought about by disturbances in the Tertiary era. The thermal springs emerging from the Deccan Trap on the Tapti valley probably owe their origin to a similar cause.

Springs in the Himalayan belt follow the tectonic trends of the mountain system. A few springs lie outside the major belts of disturbance and detailed investigations are called for to establish their connection with dislocations in the earth's crust (Ghosh, *Rec. geol. Surv. India*, 1954, **80**, 541).

Distribution

Andhra In Godavari dist., a hot spring (temp., 60°) rises in the bed of the Godavari river at Gondala (17°39′:81°0′), it emits slight odour of hydrogen sulphide and contains small quantities of sodium sulphide, sodium chloride and calcium chloride. In Kurnool dist., several springs occur near Lanjabanda (15°30′:78°3′30″), Mahanadi (15°29′:78°41′) and Kalva (15°37′:78°16′). In Gulbarga dist. springs having copious discharge occur at Wujul (16°28′30″:76°36′30″) and Mudamur (16°36′:76°33′). In Warangal dist., a spring forming a pool, 40 ft. by 30 ft. in extent and 5 ft. deep, is found near Baiora (17°56′:80°47′); the water is slightly carbonated (La Touche, 382–84).

Assam—Several thermal springs (temp., *c.* 55°) occur at Kopili (25°30′30″:92°41′) in Cachar dist. and at Nambor (26°24′:93°56′) in Sibsagar dist. (La Touche, 373).

Bihar In Bihar hot sulphur springs occur at Charak (24°1′:86°25′), Jherbari (23°42′:86°46′), Sheopur (23°40′:86°35′) and Tatloi (23°41′:86°44′) in Manbhum dist. and at Jharom (23°50′:84°30′) in Palamau dist.; alkaline springs of the Kawa Gandh-

wani series (23°44′:85°23′) are found in Hazaribagh dist. These springs are situated in Archaean terrain, in zones more or less parallel and close to the boundary of Gondwanas and are related to post-Gondwana faulting (Ghosh, *Proc. Indian Sci. Congr.*, 1948, pt II, 224).

The hot sulphur springs of Surajkund (24°9′: 85°38′) and Duari (24°8′:85°9′) in Hazaribagh dist. are situated also in Archaeans. The two cold springs in the dist., one at Patalsur (24°10′:85°37′) and the other at the summit of Pareshnath hill, are also situated in Archaean gneisses: their flow fluctuates in different times of the season, the water being derived from surface or near-surface sources.

In Monghyr dist., 'simple' or 'indifferent' thermal waters, so called on account of their low mineral content, occur in a line extending over a distance of 30 miles or more along the strike of Kharagpur hills in a zone of faulting in Archaean quartzite, with porphyritic granite occurring at the base of quartzite. All the springs, excepting Phillipskund and Sitakund at the northern extremity of the zone, are confined to Kharagpur hills. The zone in which the springs occur take a southerly direction and passes through Rishikund, Rameswarkund, Lachmiswarkund and Bhowrahkund and then turn to southwest to Bhimband (25°4′:86°24′) and Bharari (25°7′:86°21′).

The thermal springs of the Rajgir group, occurring in Patna and Gaya districts, emerge out of Archaean quartzites as in the case of Monghyr springs. There are more than a dozen of them on either side of Betarni river along the foot of Baibhargiri and Bipulagiri hills, at a distance of *c.* 1 mile from Rajgirkund railway station and at an altitude of 200 ft. The Tapoban springs (24°55′:85°19′) in Gaya dist. are situated at an altitude of 300 ft., *c.* 12 miles W.SW of Rajgir. There are four springs (Sanat, Sanatan, Sanatnandan and Sanatkumar or Brahmakund) in an east-west line along the foot of the highly jointed quartzite hill. About 8 miles E.SE of Rajgir are Agnikund springs (25°0′:85°30′) situated at an altitude of 200 ft. at the foot of a quartzite ridge.

Gujarat & Maharashtra The expanse of country in western India, covered by the vast basaltic Deccan Trap, is singularly devoid of mineral springs except for the series running north and south along the coastline between the sea and the western ghats. At the northern extremity of the series is Deoki Unai group of springs in the former Bansda state in Surat dist. (Gujarat) and at its southern end occur the Rajapur springs in Ratnagiri dist. (Maharashtra).

Beginning with the Vajreshwari springs of Thana dist., the southern portion of the series stretches over Thana, Kolaba and Ratnagiri districts. In Thana dist., at the north-western part of Bhiwandi taluk, the course of Tansa river is marked for a distance of 3 miles by a number of mineral springs, either in the river bed or close to its banks, collectively known as Vajreshwari springs (19°29′–19°30′: 73°1′–73°2′). Three groups of springs, viz. Unhera springs (18°33′:73°13′), Sov springs (18°5′:73°23′) and Vadavali springs (18°4′:73°27′), occur in Kolaba dist. Seven groups of springs viz., Khed springs (17°43′:73°24′), Unhara springs (17°37′:73°19′), Arvali springs (17°:9′:73°31′), Tural springs (17°17′: 73°32′), Rajwadi springs (17°15′:73°34′), Sangameswar (Phansavna) springs (17°12′:73°35′) and Rajapur (Unhala) spring (16°39′:73°32′) occur in Ratnagiri dist. The waters of Unhera, Unhara and Vajreshwari springs are saline (Ghosh, *Proc. Indian Sci. Congr.*, 1948, pt II, 226: *Rec. geol. Surv. India*, 1954, **80**, 545).

Madhya Pradesh—A hot spring occurs at Burra Anhoni (22°35′:78°36′) in Chhindwara dist. on the Deccan Trap formation, along the Chhindwara–Matkuli road, *c.* 8 miles from Matkuli. In Hoshangabad dist., close to Anhoni village (22°37′:78°21′) in Sohagpur tahsil, occurs another thermal spring, the Chota Anhoni spring. The waters of the two springs are low in mineral content: the Burra Anhoni spring water resembles the indifferent water of Trinkquelle-Wildbad (Germany), that of Chota Anhoni spring resembles diluted Vichy (France) water.

Mysore—In Bangalore cantonment (12°58′: 77°38′), a well containing saline water is attributed some medicinal properties. A mineral spring containing slightly carbonated water with traces of alumina and lime occurs at Ramandrug (15°7′30″: 76°32′) in Bellery dist. (La Touche, 384).

Punjab—A hot spring occurs in Sohna village (28°15′:77°8′), *c.* 34 miles from Delhi. It is used for bathing and drinking purposes and has been partly commercialized, the rights of private baths being annually auctioned. The water, like that of Chota Anhoni (Madhya Pradesh), contains bicarbonates. Occurrence of 6 mineral springs containing small amount of iodine salts and efficacious in the treatment of goitre, have been reported from Jwalamukhi (31°52′:76°23′). Saline and sulphurous springs occur

also at Lausa (32°23′:76°5′), Tatwani (32°7′:76°46′), Tiva (32°8′:76°14′), Bashist (32°16′:77°15′), Monali (32°15′:77°14′), Manikarn (32°2′:77°25′) and Pinjaur (38°48′:76°59′) (La Touche, 385).

Rajasthan—In Udaipur dist., a spring rises through sandstone at Ganger (25°3′:74°40′), the water of the spring is slightly saline and sulphurous (La Touche, 387).

Uttar Pradesh—There are two wells containing alkaline mineral water in Banaras city, viz. Bridhkal and Gaibi. The waters are similar to that of Apollinaris and Wiesenbrunnens.

In Dehra Dun dist., a group of cold springs occur in the limestone-bearing terrain near Mussoorie (30°27′:78°4′). Of these, the Mossy Fall spring gives simple or indifferent water of the Evian type. The Sahasradhara sulphur spring (30°23′:78°7′), situated c. 7 miles N.NE of Dehra Dun and 2½ miles E.SE of Rajpur, issues through limestone in the gorge of the upper reaches of Baldi Nadi. The water of the spring is reported to possess curative properties.

Characteristics of Spring Waters

Table 1 gives the characteristics of some of the more prominent springs revealed by the survey in the States of Bihar, West Bengal, Madhya Pradesh, Gujarat, Maharashtra, Punjab and Uttar Pradesh.

The geological environment influences the composition and radio-active character of the waters. As a rule, waters emanating from Archaean terrain are fairly low in mineral content, e.g. those of Bihar, Birbhum dist. (West Bengal) and Gurgaon dist. (Punjab). Those emerging from basalt, as in Maharashtra and Madhya Pradesh, are high in mineral content, alkaline earths, magnesium and sulphate and chloride predominating. On the other hand, springs emanating from limestone, e.g. those of Dehra Dun, are high in calcium carbonate and bicarbonate with varying amounts of sulphate.

Temperature—The waters from some springs emerge hot, while from others either lukewarm or cold. The highest temperature of spring water recorded in India is 87° at Surajkund (Hazaribagh dist., Bihar). The temperature remains fairly uniform. The main Surajkund spring lies within a few feet of 5 other springs emerging at much lower temperatures.

A high temperature indicates that the water is of deep-seated origin. The temperature decreases as the water travels upwards by admixture with circulating water in the shallower portions of the earth's crust. Cold springs are of superficial origin and unlike hot springs, are liable to be contaminated, as they draw their supply of water from surface or near-surface sources.

Flow—The flow of water, particularly in cold springs, is larger during the rainy season and early winter than in summer. The highest flow recorded is 38,000 gal./hr. from Sitakund (Monghyr dist., Bihar).

Radio-activity—With the exception of a few springs in Maharashtra, the waters of which are permanently radio-active, most springs examined by the Geological Survey show radio-emanative properties which almost disappear in the course of a month. This is due to the presence of radon (half life period, 3.8 days), derived from the spontaneous disintegration of radio-active elements present in the earth's crust through which the water circulates. On the basis of radio-activity, Indian springs have been divided into four categories, viz. very strongly radio-active (radon content, 17.7–6.1 mMc); strongly radio-active (radon content, 5.06–2.80 mMc); mildly radio-active (2.19–1.00 mMc); and feebly radio-active (0.98–trace mMc). Very strongly radio-active springs occur mostly in Bihar in Palamau, Hazaribagh and Monghyr districts. Some springs of the Rajgir series in Patna and Gaya districts have also been found to possess very strong radio-activity. The highest activity of 17.7 mMc was recorded at Jarom in Palamau dist. Springs in Maharashtra and Uttar Pradesh (Dehra Dun dist.) and wells in Bharatpur (Rajasthan), and Banaras (Bridhkal and Gaibi) are feebly active (Table 1) (Chatterjee, *Indian Miner.*, 1958, **12**, 116).

Chemical composition—From the point of view of chemical composition, Indian spring waters fall under four main types, viz. (*i*) simple or indifferent, characterized by low mineral content; (*ii*) alkaline, contain sodium carbonate and bicarbonate; (*iii*) sulphur waters characterized by the presence of hydrogen sulphide and often sulphate radicals; and (*iv*) chloride or saline waters.

The mineral content of simple waters seldom exceeds 500 p.p.m. and is often as low as 40 p.p.m. The waters of Mossy Fall, Mussoorie and of thermal waters of Rajgir in Patna and Gaya districts and those of Kharagpur hills of Monghyr dist. fall under this class. Mossy Fall waters compare favourably with foreign waters and have been found to be similar to Evian type of waters. The waters of Rajgir and Kharagpur hills are slightly acidic or alkaline;

TABLE 1—CHARACTERISTICS OF SOME INDIAN SPRINGS*

Location	Gases, if any	Rate of flow (gal./hr.)	Temp. °C.	Radons (mMc/litre)	Therapeutic uses
BIHAR AND WEST BENGAL					
Manbhum dist.					
Charak (Main)	Hydrogen sulphide & carbon dioxide	500	38	1.150	
Sheopur (Main)	do.	250	40	1.227	
Tatloi (No. 1)	do.	4,000	60	0.245	
Usir	None	5	31	7.779	
Birbhum dist.					
Bakreswar springs:					
Agnikund	Carbon dioxide	1,200	71	2.805	Skin diseases, digestive disorders and rheumatism; acts as appetizer
Brahmakund	None	1,200	42	0.791	
Hazaribagh dist.					
Kawa Gandhwani	Hydrogen sulphide	1,150	34–35	8.561–8.380	do.
Duari	do.	500	45	3.280	do.
Hatkauna	None	100	22	0.345	
Surajkund	Hydrogen sulphide & carbon dioxide	3,000	87	1.410	Skin diseases, digestive disorders and rheumatism; acts as appetizer
Patalsur	None	200 (in April 1941)		10.382	
Pareshnath (east of temple)	do.	4,000 (in Sept. 1941) 117 (in April 1941)	20	0.019	
Monghyr dist.					
Bharari springs	Carbon dioxide	7,000	58–65	0.224–0.290	Skin diseases, gout, rheumatism; appetizer and corrective for metabolic disorders
Bhimbandh springs (1–4)	do.	10,000	52–64	0.765–1.224	do.
Bhowrah (West)	do.	2,000	44	4.450	do.
do. (East)	do.	1,000	40	9.270	do.
Lachmiswarkund	None	7,200	67	0.983	do.
Lake (1 mile south of Phillipskund & Sitakund)	None	Permanent lake	..	0.308 (unused	
Phillipskund	Carbon dioxide	10,500	55	3.046	Skin diseases, gout, rheumatism; appetizer and corrective for metabolic disorders
Rameswarkund	Carbon dioxide	3,600	44	7.850	do.
Rishikund—Gr. I	do.	5,000	40	4.920	do.
Rishikund, north of temple	do.	3,000	45	5.065	do.
Rishikund—Gr. II	do.	5,000	39	5.060	do.

TABLE 1—*contd.*

Location	Gases, if any	Rate of flow (gal./hr.)	Temp. °C.	Radons (mMc/litre)	Therapeutic uses
Rishikund—Gr. III	Carbon dioxide	1,500	46	3.560	Skin diseases, gout, rheumatism; appetizer and corrective for metabolic disorders
Rishikund, southernmost of the group	do.	5,000	44	4.853	do.
Shringirikh (with spout)—I	None	9,500	31	3.048	do.
Shringirikh, east of I	None	3,500	29	3.052	do.
Sitakund	Carbon dioxide	38,000	57	3.050	do.
Palamau dist.					
Jarom	Hydrogen sulphide & carbon dioxide	250	55.5	17.700	do.
Santhal Parganas					
Barhmasia	do.	500	32	0.925	..
Jharipani	Hydrogen sulphide & carbon dioxide	3,000	33	0.336	..
Kaldam, Bara	None	100	25	0.134	..
Rampur (west of Jiajori)	Hydrogen sulphide & carbon dioxide	1,782	31	2.197	..
Tanteswari	do.	5,000	69	2.061	Skin diseases; appetizer
Tantloi	do.	5,000	65.5	0.141	do.
Trikut Pahar	None	65	22	0.018	..
Patna & Gaya districts					
Rajgir springs:					
Brahmakund	Traces of inert gases, possibly nitrogen	8,000	42.5	6.870	Skin diseases, rheumatic complaints, paralysis, dyspepsia and diabetes
Makhdumkund	None	1,436	36	4.130	do.
Chandramakund	do.	200	40	6.590	do.
Surajkund	do.	575	41	6.200	do.
Vyaskund	do.	1,044	41	3.576	do.
Viswamitrakund	None	1,436	41.5	1.380	do.
Gangakund	do.	760	42	3.580	Skin diseases, rheumatic complaints and dyspepsia
Jamunakund	do.	415	41.5	3.600	do.
Markandevakund	do.	125	39.5	1.730	do.
Ramkund (hot spout)	do.	55	32	1.003	do.
do. (cold spout)	do.	10	23.5	Tr.	do.
Sitakund	do.	290	40	6.200	do.
Ganeshkund	Hydrogen sulphide	n.a.	n.a.	n.a.	do.
Tapoban springs:					
Agnikund	Hydrogen sulphide & carbon dioxide	9,000	50	4.234	Skin diseases

TABLE 1 *contd.*

Location	Gases, if any	Rate of flow (gal./hr.)	Temp. °C.	Radons (mMc/litre)	Therapeutic uses
GUJARAT & MAHARASHTRA					
Thana dist.					
Lachmankund	Hydrogen sulphide & carbon dioxide	700	50	0.424	Skin diseases, rheumatism, gout, paralysis, obesity, goitre and elephantiasis; appetizer
Chandrakund	do.	260	50	0.585	do.
Vajreshwari (spring No. 8)	do.	60	44	nil	do.
Gangakund	do.	200	31	do.	do.
Surajkund	do.	600	50	do.	do.
Bhimeshwarkund	do.	400	51	do.	do.
Anusaichikund	do.	600	56	do.	do.
Agnikund	Carbon dioxide & inert gases	1,000	58	do.	Skin diseases and rheumatic complaints; appetizer
Kothavala's spring	do.	310	52	0.066	do.
Kolaba dist.					
Unhera	Carbon dioxide	410	41.5	nil	do.
Sov	Hydrogen sulphide & carbon dioxide	600		do.	do.
Ratnagiri dist.					
Khed	Hydrogen sulphide & carbon dioxide	140		nil	do.
Unhara	do.	1,500	69	0.806	do.
Aravali	do.	916	40	nil	do.
Rajwadi	do.	1,870	54	do.	do.
Tural	do.	1,000	61	do.	do.
Sangameshwar (Phansavna)	Carbon dioxide	..	52	do.	do.
Rajapur (Unhala)			60	do.	do.
MADHYA PRADESH					
Chhindwara dist.					
Burra Anhoni	Hydrogen sulphide & carbon dioxide	1,500	56	Tr.	do.
Hoshangabad dist.					
Chota Anhoni	do.	1,100	45	nil	Skin diseases
PUNJAB					
Gurgaon dist.					
Sohna	do.	880	46	2.930	Leprosy and other cutaneous affections, scrofula, rheumatism and liver complaints

TABLE 1—*contd.*

Location	Gases, if any	Rate of flow (gal./hr.)	Temp. C	Radons (mMc/litre)	Therapeutic uses
UTTAR PRADESH					
Varanasi dist.					
Bridhkal well	Hydrogen sulphide & carbon dioxide	A constant level of 40 ft. of water maintained	25	0.525	Leprosy and other cutaneous affections, scrofula, rheumatism and liver complaints
Gaibi well	None	do.	25	0.250	do.
Dehra Dun dist.					
Springs in and around Mussoorie		400–10,000	17–21	Trace to 0.810	
Sahasradhara	Hydrogen sulphide	25,000		0.273	Skin diseases and digestive complaints

* Ghosh, *Rec. geol. Surv. India*, 1954, **80**, 554–58.
Tr.—Traces.
n.a.—not available.

TABLE 2—CHEMICAL ANALYSES OF INDIFFERENT WATERS*
(in parts per million)

	Simple type		Acid type
	Mossy Fall (U.P.)	Evian (France)	Brahmakund (Rajgir)
Sodium	13.0	6.9	2.0
Potassium	Tr.	2.3	nil
Magnesium	12.2	23.7	Tr.
Calcium	50.6	78.4	11.4
Iron & Aluminium	2.0	0.2	nil
Chloride (Cl)	6.0	1.8	4.0
Sulphate (SO_4)	152.0	8.5	Tr.
Bicarbonate (HCO_3)	177.0	356.8	24.0
Silicate ($HSiO_3$)	12.1	18.2	25.6

* Ghosh, *Rec. geol. Surv. India*, 1954, **80**, 547.
Tr.—Traces.

TABLE 3—CHEMICAL ANALYSES OF ALKALINE WATERS*
(in parts per million)

	Kawa Gandhwani	Sohna	Chota Anhoni	Vichy water (dil. 10 times)
Silica	56.0	44.0	14.0	4.6
Iron	nil	nil	0.7	Tr.
Aluminium	11.4	46.7		
Calcium	nil	11.4	16.7	7
Magnesium	nil	3.6	..	3
Sodium	109.0	123	188.9	97
Bicarbonate (HCO_3)	185.0	270	221.4	234
Sulphate (SO_4)	7.0	11	nil	11.3
Chloride (Cl)	39.0	199	59.0	18.2
Fluoride (F)	17.0	nil	nil	1.8

*Ghosh, *Rec. geol. Surv. India*, 1954, **80**, 550.
Tr.—Traces.

some of them are used as table waters. The characteristics and chemical analysis of simple type indifferent waters of Mossy Fall (U.P.) and Evian (France), and of acid type indifferent waters of Brahmakund spring are given in Table 2. Alkaline waters of Bridhkal and Gaibi wells of Banaras show similarities to Apollinaris and Wiesenbrunnens waters. Mild Vichy type of water (with varying amount of hydrogen sulphide) is obtained at Kawa Gandhwani in Hazaribagh dist., Chota Anhoni in Hoshangabad dist. (Madhya Pradesh), and Sohna in Gurgaon dist. (Punjab). Chemical analyses of these spring waters and of diluted Vichy water is given in Table 3. Thermal springs of Duari and Surajkund in Hazaribagh dist. resemble the water of Aix-les-Bains spring; comparative analytical data of the waters of these springs along with the analysis of the water of Taylor Spring (California, U.S.A.) are given in Table 4. Chloride or saline waters of Unhara spring (Ratnagiri dist.) and Surajkund (Vajreshwari, Thana dist.) of Maharashtra resemble the waters of Marienquelle and Leamington (Table 5). The comparative data given in Tables 2, 3, 4 and 5 aim at establishing only general similarities between one water and another as it is difficult to find two waters containing exactly the same constituents in identical proportions.

TABLE 4—CHEMICAL ANALYSIS OF WARM SULPHUR WATERS*
(in parts per million)

	Duari (India)	Surajkund (India)	Aix-les-Bains (France)	Taylor Spring (California U.S.A.)
Sodium	128	146	34	93
Potassium	..	..	..	6.3
Magnesium	nil	Tr.	19	35
Calcium	2.9	2.9	64	7
Iron	nil	nil	4.2	Tr.
Aluminium	4.24	nil	8.7	8.4
Carbonate & bicarbonate	121	123	112	35.0
Sulphate (SO_4)	38	65	151	220
Sulphide (S)	20	..	34	13
Chloride (Cl)	71	92	18	59
Fluoride (F)	18	21	..	..
Silicic acid ($HSiO_3$)	87.26	164.26	6.40	25.60

* Ghosh, *Rec. geol. Surv. India*, 1954, **80**, 552.
Tr.—Traces.

TABLE 5—CHEMICAL ANALYSIS OF SALINE WATERS*
(in parts per million)

	Unhara (India)	Surajkund, Vajreswari (India)	Leamington (England)	Marienquelle (Germany)	Arondark (America)
Sodium	669.4	710.1	714.0	972	827
Magnesium	..	..	78.5	40	91
Calcium	153.0	153.7	272.6	123	26
Iron	3.0	..	4.2	2.7	..
Chloride (Cl)	1090.9	1241.0	1259.1	1566.0	1186
Sulphate (SO_4)	274.2	155.5	498.6	Tr.	504
Carbonate (CO_3)	8.0	9.2	150.4	228	136
Bicarbonate (HCO_3)	..				
Fluoride (F)	..				
Silicate ($HSiO_3$)	5.1	6.42	32.9	?	11.8

* Ghosh, *Rec. geol. Surv. India*, 1954, **80**, 553.
Tr.—Traces.

UTILIZATION

Only a few springs are used for baths, although there is scope to develop most of them as attractive spa resorts and bottle their waters as table and medicinal waters.

The Geological Survey of India tested the efficacy of bottled waters and found them to be as good as table and medicinal waters used in other countries. The reported therapeutic properties of some springs are given in Table 1.

Mint — *see* **Mentha**

Mint, Cat — *see* **Nepeta**

MIRABILIS Linn. (*Nyctaginaceae*)

A genus of herbs, sometimes shrubs, mostly native of America. Some species are ornamental and are cultivated, or have become naturalized, in the warmer parts of the world. One species occurs in the Himalayas and three exotic species are grown in gardens.

M. jalapa Linn. FOUR O'CLOCK PLANT, MARVEL OF PERU

D.E.P., V, 253; Bailey, 1949, 358.

HINDI—*Gul-abbas, gulabash*; BENG.—*Krishnakeli, sarpamani*; MAR.—*Gulbas*; GUJ.—*Gubbaji*; TEL.—*Chandrakanta, chandramalli*; TAM.—*Andhimalligai*; KAN.—*Sanjamallige, chandramallige*; MAL.—*Antimalari, antimantarum*.

A perennial herb or undershrub, c. 1.0 m. high, grown for ornament throughout India: it is met with as an escape in many places. Roots thickened and tuberous, up to 10 cm. or more in diam.; stems swollen at nodes; leaves ovate, cordate; flowers in clusters, funnel-shaped, simple or double, fragrant, white, yellow, purple or red, striped or blotched; nut ellipsoid, rugose, 1-seeded.

The plant is propagated by seeds or by root tubers of the previous year and grown in pots, shrubberies or perennial borders. Flowers are borne in profusion: they open late in the afternoon and close in the morning (Gopalaswamiengar, 496; Bailey, 1947, II, 2056).

The tuberous roots of the plant were once erroneously thought to be the source of jalap (*Exogonium purga*). They are dark brown in colour and show a horny fracture. They are mildly purgative and used as a substitute or adulterant of true jalap. In powdered form, the roots possess a distinct odour and a slightly acrid taste followed by a tingling warm and numbing sensation, stimulating the flow of saliva. Moistened powder is irritant to skin and

mucous membrane. The roots contain a resin (3%); trigonelline and a carbohydrate yielding galactose and arabinose on hydrolysis, are present. Mature fruits yield a starch completely soluble in water at 28° (Youngken, 694–95; B.P.C., 1959, 392; Wehmer, I, 299; Chaudhuri, *Sci. & Cult.*, 1946–47, **12,** 449).

The leaves and stems of the plant are reported to be cooked with pork and used as tonic in China. Seeds are used as an adulterant of black pepper. Bruised leaves are employed for poulticing abscesses and boils. Juice expressed from leaves is used as an external application to wounds and bruises and for allaying itching in urticaria [Cheo, *Bot. Bull. Acad. sinica,* 1947, **1**(4), 298; Kirt. & Basu, III, 2050; Burkill, II, 1478–79; Nadkarni, I, 803].

M. himalaica (Edgew.) Heimerl syn. *Oxybaphus himalaicus* Edgew. is a herb found in western Himalayas from Kulu to Garhwal, at altitudes of 1,800–2,700 m. It is used as winter fodder.

MISCHOCARPUS Blume (*Sapindaceae*)

Fl. Br. Ind., I, 678.

A small genus of trees distributed from South-East Asia to Australia. Three species are found in India.

M. sumatranus Blume syn. *Cupania sumatrana* Miq. is a small tree up to 12 m. in height with pinnate leaves, small whitish flowers and pear-shaped red capsules, recorded from Khasi hills in Assam. The fruits are reported to be eaten in Malaya.

M. sundaicus Blume syn. *Cupania lessertiana* Cambess.; (Fl. Br. Ind.) in part is a closely related species found in South Andaman Islands. The young shoots are said to be edible. The wood is reported to be used for making charcoal in Java (Burkill, II, 1480; Corner, I, 588).

MISCHODON Thw. (*Euphorbiaceae*)

Fl. Br. Ind., V, 344.

A genus of trees distributed in South India and Ceylon. *M. zeylanicus* Thw. (TAM.—*Tampanai*), a large, handsome, evergreen tree with brown, rough bark and linear-oblong leaves, is reported to occur in the Anaimalai and Tinnevelly hills. The wood is pinkish or brown in colour, close- and even-grained, hard and heavy. It is durable, withstands moisture and works to a smooth surface under tools; it is reported to be suitable for decorative work and turnery. In Ceylon, it is said to be used for building purposes (Gamble, 607; Howard, 371; Lewis, 335).

Mistletoe — *see* **Viscum**

Mithan — *see* **Wild Cattle, Sheep and Goats**

MITRAGYNA Korth. (*Rubiaceae*)

A genus of shrubs or trees distributed in the tropics of the Old World. Three species are found in India.

M. parvifolia (Roxb.) Korth. syn. *Stephegyne parvifolia* Korth.

D.E.P., VI(3), 360; Fl. Br. Ind., III, 25.

FIG. 143. MISCHODON ZEYLANICUS—FLOWERING BRANCH

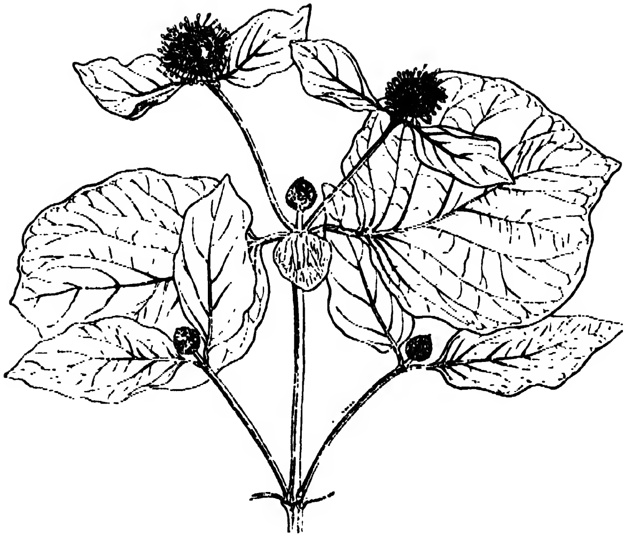


FIG. 144. MITRAGYNA PARVIFOLIA—FLOWERING BRANCH

HINDI—*Kaim, kalmi, kadassa;* BENG.—*Gulikadam* ; MAR.—*Kalamb, kuddam* ; GUJ.—*Kadamb* ; TEL.—*Nir kadambe* ; TAM.—*Chinna kadambu* ; KAN.—*Kongu, kadaga* ; MAL.—*Vimbu, nirkadambu* ; ORIYA —*Gudikaima, mundi, mur.*

TRADE—*Kaim.*

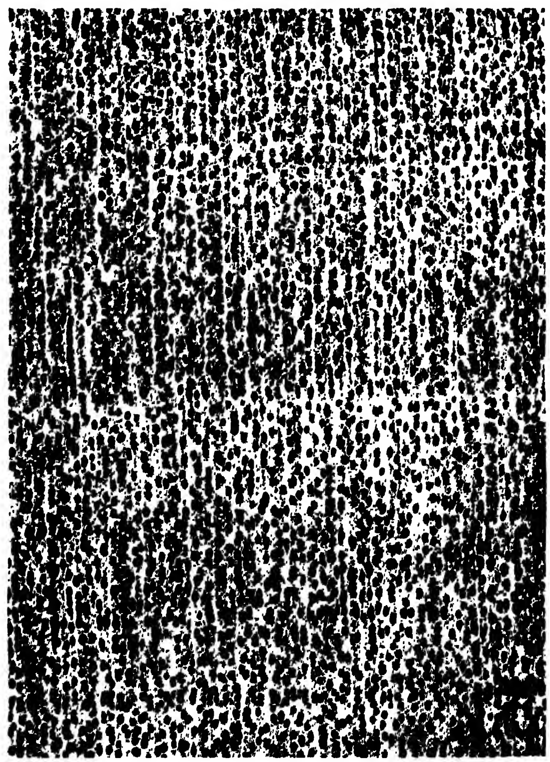
A medium-sized to large deciduous tree with rounded crown found throughout the greater part of India, ascending up to an altitude of 1,200 m. in the outer Himalayas. Bole often short, fluted, buttressed ; bark grey, smooth, exfoliating in scales ; leaves variable, elliptic, sub-orbiculate or obovate ; flowers in globose heads, greenish yellow, fragrant ; capsules oblong ; seeds minute, winged.

The tree is generally found scattered in deciduous forests and develops best in well-drained deep soil. It can also tolerate stiff and badly drained ground and often grows gregariously in low-lying areas around banks and swamps, where it generally remains stunted. In the Deccan Peninsula, it is found on black cotton soil and alluvial ground near rivers. In the early stages, the tree stands a certain amount of shade, but later becomes a light demander. It is fairly drought-hardy. It coppices well up to a moderate size (Troup, II, 622–23).

Natural reproduction takes place by seeds scattered in the hot season ; some seeds remain in fruiting heads and germinate after they fall to the ground. Germination takes place early in the rainy season. Natural reproduction sometimes comes up freely on abandoned cultivation and also on badly drained ground. For artificial reproduction, seedlings raised in boxes are transplanted when 2–3 months old. The tree grows moderately fast, the mean annual girth increment being 0.7 in. (Troup, II, 623).

The wood is pale yellow when first exposed, ageing to light greyish brown ; straight- or broadly wavy-grained, fine- and even-textured ; strong, hard and moderately heavy (sp. gr., c. 0.63 ; wt., 40 lb./cu.ft.). It is liable to develop fine wavy surface cracks and splits at knots. Green conversion, followed by stacking in a sheltered place to prevent rapid drying is recommended. The wood can be kiln-seasoned in 13–16 days ; in addition to initial steaming, it needs two intermediate and one final steaming at 55°C./100% R.H. for 2–4 hr. The timber is fairly durable if not exposed ; graveyard tests indicate a durability of 4 years. Its behaviour to preservative treatment is erratic ; penetration in some pieces is complete, in others it is patchy (Pearson & Brown, II, 631–33 ; Trotter, 1944, 139 ; Rehman, *Indian For.*, 1953, **79**, 369).

The wood is easy to saw and work, but if wavy or broadly interlocked fibres are present, considerable care is necessary to bring it to a smooth surface. It takes a fine polish and stains easily. When cut to show



F.R.I., Dehra Dun. Photo : S. S. Ghosh

FIG. 145. MITRAGYNA PARVIFOLIA—TRANSVERSE SECTION OF WOOD (× 10)

interlocked banding to advantage, it is quite attractive (Pearson & Brown, II, 633; Trotter, 1944, 139).

The data for the comparative suitability of timber, expressed as percentages of the same properties of teak, are: wt., 95; strength as a beam, 75; stiffness as a beam, 70; suitability as a post, 75; shock-resisting ability, 95; retention of shape, 65; shear, 110; and hardness, 100. The timber is commonly used as planks and rafters in building construction and for furniture, agricultural implements, cooperages, utility brushes and boot lasts. It is used also for turnery and carving. It is reported to be suitable for match boxes and splints, calico printing blocks and slate frames, and has been recommended for penholders, mathematical instruments and shuttles (Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** Sheet No. 14; Pearson & Brown, II, 633; Trotter, 1944, 139-40, 200, 207, 209, 214, 224; Rama Rao, 202; Rehman & Askari, *Indian For. Bull., N.S.*, No. 199, 1956, 5; Rehman *et al.*, *Indian For.*, 1954, **80,** 626).

Destructive distillation of kaim wood gave the following products (dry basis): charcoal, 34.1; total distillate, 45.1; pyroligneous acid, 36.2; acid (as acetic), 4.12; ester (as methyl acetate), 4.09; ketones and aldehydes (as acetone), 2.92; methanol, 1.14; tar, 8.9; and pitch and losses, 2.1%; gas (at N.T.P.), 1.88 cu.ft./lb. The wood yields 1.91% ash containing *c.* 50% lime (CaO). Calorific value of the sapwood: 4,086 cal., 7,355 B.t.u. (Kedare & Tendolkar, *J. sci. industr. Res.*, 1953, **12B,** 217, 125; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 23).

The tree is lopped for fodder. Analysis of leaves gave the following values (dry basis): crude protein, 7.73; ether extr., 3.27; N-free extr., 60.65; crude fibre, 19.57; total ash, 8.78; calcium (CaO), 3.17; and phosphorus (P_2O_5), 0.56%; digestible crude protein, 1.47; total digestible nutrients, 50.0; and starch equivalent, 38.56 lb./100 lb. The leaves are rich in tannin (2.1% as gallotannic acid, dry basis). Feeding trials with Kumaoni bullocks showed that the leaves are not relished, resulting in poor consumption. The animals showed positive balances for nitrogen and calcium and negative balance for phosphorus (Joshi *et al.*, *Proc. Indian Sci. Congr.*, 1953, pt III, 242; Goswami & Kehar, ibid., 1956, pt III, 359).

The bark and root of the tree are used for fevers and colic. The bark yields a cordage fibre. The plant contains a crystalline alkaloid (0.15%), a gum, a resin and a wax (Kirt. & Basu, II, 1256; *Chem. Abstr.*, 1934, **28,** 1041).

M. rotundifolia (Roxb.) Kuntze syn. *M. diversifolia* Korth.; *Stephegyne diversifolia* Hook. f.

D.E.P., VI(3), 360; Fl. Br. Ind., III, 26.

ASSAM—*Timi*; LUSHAI *Thinglung, lungkhup.*

TRADE *Binga.*

A moderate-sized deciduous tree with a straight, fairly cylindrical bole found in the hills of Assam up to an altitude of 1,500 m. and in the Andaman Islands. Bark rough, longitudinally fissured; leaves broadly ovate to elliptic or sub-orbicular; flowers in small heads, geenish white; capsules obovate-oblong; seeds minute, winged.

Natural reproduction is abundant on alluvial land along rivers and streams; seedlings often come up on abandoned cultivation (Troup, II, 624).

The wood is creamy white when first exposed, ageing to pale yellowish brown, generally straight- but somewhat uneven-grained in the radial plane, fine- and quite even-textured; hard, brittle and moderately heavy (sp. gr., *c.* 0.6; wt., 41 lb./cu.ft.). It air-seasons well; green conversion followed by protection of stock is recommended. It can also be kiln-seasoned with comparatively little degrade. The wood is fairly durable when not in contact with ground; graveyard tests indicate a durability of 40 months (Pearson & Brown, II, 634-36; Gamble, 404; Purushotham *et al.*, *Indian For.*, 1953, **79,** 49).

The wood saws well and lends itself to working by hand and machine: it turns well on the lathe if seasoned. The comparative suitability of binga wood, expressed as percentages of the same properties of teak, are: wt., 95; strength as a beam, 95; stiffness as a beam, 85; suitability as a post, 90; shock-resisting ability, 105; retention of shape, 65; shear, 110; and hardness, 105 (Pearson & Brown, II, 636; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** Sheet No. 14).

The wood is used for buildings, packing cases, photo-printing blocks, file and chisel handles and musical instruments and for carving and turnery. It has been recommended for jute bobbins, boot lasts and parquetting (Pearson & Brown, II, 636; Rodger, 4, 71, 134-35).

Following alkaloids have been isolated from the leaves and bark of the tree: mitraversine ($C_{22}H_{26}O_4N_2$, m.p. 237°), rhyncophylline or mitrinermine ($C_{22}H_{28}O_4N_2$, m.p. 208-09°), rotundifoline ($C_{22}H_{26}O_5N_2$, m.p. 233-34°) and mitragynol ($C_{21}H_{26}O_4N_2$, m.p. 130°). Rhyncophylline lowers blood pressure and paralyses sympathetic nerve endings (Henry, 756-58; Badger *et al.*, *J. chem. Soc.*, 1950, 867).

M. tubulosa (Arn.) Kuntze syn. *Stephegyne tubulosa* Hook. f. (TAM.—*Naikadambu*; MAL.—*Malan thumba*) is a small to moderate-sized tree found in Kerala. The wood is pinkish brown with close compact grain and works to a smooth surface. It is similar to the wood of *M. parvifolia* and used for the same purposes (Howard, 559; Bourdillon, 189).

MITREPHORA Hook. f. & Thoms. (*Annonaceae*)

Fl. Br. Ind., I, 76; King, *Ann. R. bot. Gdn Calcutta*, 1893, **4**, 111.

A genus of trees and shrubs distributed from South-East Asia to New Guinea. Four species are recorded in India.

M. heyneana Thw. is a small or medium-sized tree found in the Nilgiris, Palni and western ghats in Travancore and Tinnevelly up to an altitude of *c.* 600 m. The wood (wt., 60 lb./cu. ft.) is pale yellow, strong, moderately hard, smooth and straight-grained. It is suitable for rafters (Bourdillon, 8; Lewis, 7).

M. tomentosa Hook. f. & Thoms. (ASSAM—*Kolti, koliori*) is a small or medium sized evergreen tree found in the hills of Assam. The wood (wt., *c.* 50 lb./cu. ft.) is whitish, compact and even-grained. It is liable to split, but is said to be used for posts etc. (Fl. Assam, I, 38).

MNESITHEA Kunth (*Gramineae*)

Fl. Br. Ind., VII, 158.

A genus of slender, erect, perennial grasses distributed in South-East Asia. One species, *M. laevis* (Retz.) Kunth syn. *Rottboellia perforata* Roxb.; *Mnesithea perforata* Haines (TEL.—*Panuku, kolupugaddi*; KAN.—*Sunku dabbai hullu*; C.P. & BERAR—*Sontar*), is an erect or somewhat decumbent grass, 0.6–1.2 m. high, with linear, narrow leaves found nearly throughout India. It is common in moist areas. It is said to be of no value as fodder in some parts of India and used sometimes for thatching. But elsewhere, it has been reported to be a good fodder eaten by cattle when young. Analysis of the grass (from Indonesia) gave the following values (dry basis): protein, 3.93; fat, 0.75; carbohydrates, 42.37; fibre, 44.23; and ash, 8.72% (Witt, 232; Fl. Madras, 1761; Rhind, 76; Walandouw, *J. sci. Res. Indonesia*, 1952, **1**, 201).

Mock Strawberry — *see* **Duchesnea**

Modecca — *see* **Adenia**

MODIOLA Moench (*Malvaceae*)

Fyson, I, 57.

A monotypic genus, represented by *M. caroliniana*, native of America and S. Africa.

M. caroliniana G. Don syn. *M. multifida* Moench is a small, much-branched prostrate herb with long-petioled, roundish, deeply cut leaves and small, pink flowers. It is reported to be introduced and naturalized in Ootacamund, covering the bank of streams. The plant is suspected to be poisonous, causing staggers in sheep in Australia (Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 104; Connor, *Bull. Dep. sci. industr. Res. N.Z.*, No. 99, 1951, 46).

Molasses Grass — *see* **Melinis**

MOLLUGO Linn. (*Aizoaceae*)

A small genus of herbs distributed throughout the warmer regions of the world extending into Europe and N. America. Four species occur in India.

M. cerviana Ser.

D.E.P., V, 254; Fl. Br. Ind., II, 663; Fl. Malesiana, Ser. I, **4**(3), 268; Kirt. & Basu, Pl. 473C.

BENG.—*Ghimasak*; MAR.—*Pada*; TEL.—*Parpatakamu*; TAM.—*Parpadagam*.

An erect slender annual, 7.5–20.0 cm. high, found in dry and sandy localities in upper Gangetic plain, Rajasthan, Gujarat, Deccan, Carnatic and Orissa (Puri). Leaves in whorls of 4–8 at each node: radical leaves rosulate, spathulate, linear-spathulate or obovate, cauline leaves falsely whorled or opposite, linear-oblong or sub-spathulate; flowers numerous, in cymes; capsules globose with many pink-chestnut or yellowish seeds; root aromatic.

The herb is considered stomachic, aperient and antiseptic; flowers and tender shoots are diaphoretic and given in fevers. An infusion of the plant is given to promote lochial discharge. Oil in which roots are boiled is used as an application for gout and rheumatism. An alcoholic extract of the plant shows anti-bacterial activity against *Escherichia coli* (Nadkarni, I, 804; Kirt. & Basu, II, 1186; George *et al.*, *J. sci. industr. Res.*, 1947, **6B**, 42).

M. nudicaulis Lam.

Fl. Br. Ind., II, 664.

MADRAS—*Parppadagam*.

An erect slender annual found in the hotter parts of India. Leaves radical, crowded, oblong-spathulate or elliptic; flowers dull white, in di- and tri-chotomous cymes; capsules ellipsoid with many black seeds.

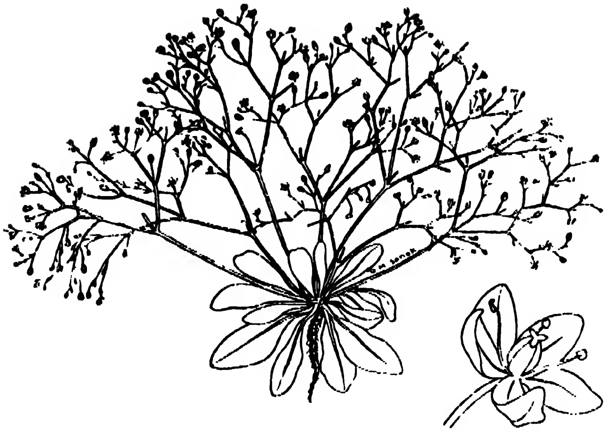


FIG. 146. MOLLUGO NUDICAULIS—FLOWERING BRANCH

The plant is bitter and considered pectoral; it is used in athrepy and whooping cough. Leaves are applied to boils to draw out pus. Six saponins have been separated from the plant (Kirt. & Basu, II, 1186–87; Dalziel, 30; *Chem. Abstr.*, 1959, **53,** 17246).

M. pentaphylla Linn. syn. *M. stricta* Linn.

D.E.P., V, 255; Fl. Br. Ind., II, 663; Fl. Malesiana, Ser. I, **4**(3), 268; Kirt. & Basu, Pl. 473B.

BENG.—*Khet-papara, julpapra*; MAR.—*Jharasa*; TEL.—*Verrichatarasi*; TAM.—*Parpadakam*; MAL.—*Parpadakapullu*; ORIYA—*Pita-gohun.*

MUNDARI—*Marakata, pirigarundi.*

An erect slender, much-branched annual, up to 30 cm. high, common in dry as well as moist areas, stony localities, rocky patches, cultivated fields, waste places and along railway lines, almost throughout India ascending up to 1,500 m. in the hills. Leaves falsely whorled or opposite, linear-lanceolate to obovate; flowers white, greenish, orange or pink, in terminal compound cymes; capsules globose with many dark reddish brown seeds; root fragrant.

The plant is eaten as pot-herb. It contains carotene (3.6 mg./100 g.), traces of vitamin C, a saponin and potassium nitrate. It is considered stomachic, aperient, antiseptic and emmenagogue and is used in poultices for sore legs. Leaves are bitter and antiperiodic; they are warmed after smearing with oil and applied to the ear to relieve earache (Basu *et al.*, *J. Indian chem. Soc.*, 1947, **24,** 358; Burkill, II, 1484; Kirt. & Basu, II, 1185; Nadkarni, I, 805).

Mollugo spp. — *see* **Glinus**

MOLLUSCS (Phylum *Mollusca*)

Pelseneer, pt V, Mollusca, 1906; Fn. Br. Ind., Mollusca, I–III, 1908–21; Hornell, Indian Molluscs, 1951.

Molluscs are soft-bodied invertebrates comprising such diverse forms as whelks, snails, slugs, oysters, cuttlefish, squids, octopods, nautilus, etc. Though externally varying, they are remarkably uniform in internal organization: the body is divisible into three regions, viz. anterior or head region; ventral region or foot, which is the chief organ of locomotion; and dorsal region or mantle, covered (in a majority of forms) by a protective shell, formed of the secretion of the mantle itself. Shell of a mollusc is composed of an outer horny layer, a median prismatic layer of lime salts and an inner pearly nacreous layer; it is greatly variable in shape, structure and colour, forming an outstanding external feature in the animal.

Molluscs are distributed throughout the world and are essentially aquatic. Most of them inhabit the sea; some live in estuaries and fresh water while others are terrestrial. Generally they are free living and sluggish: they move about by crawling, swimming, burrowing, and even climbing; some are strong swimmers and predatory in habit. A few live floating in the sea. More than 70,000 species of molluscs are known and they range in size from snails less than 1 mm. in length to giant squids more than 15 m. long.

Phylum *Mollusca* is divided into five classes, viz. *Amphineura, Gastropoda, Scaphopoda, Lamellibranchia* (*Pelecypoda* or *Bivalvia*) and *Cephalopoda*; of these the following three classes alone are economically important.

Gastropoda—This constitutes the largest class of molluscs containing 30,000–40,000 species and includes snails, slugs, limpets, whelks, periwinkles, etc. The most characteristic feature of the class is the spirally coiled shell of one piece; the shape of the shell, however, varies greatly. Rarely, as in sea slugs, the shell is either reduced or absent; in cowries, it is partly covered. Nearly 200 families of gastropods are known; they inhabit the land, fresh as well as salt waters. Most of the gastropods are vegetarians and the land forms are usually found on and under plants; in the sea, the shallow waters of the littoral zone with abundant seaweeds form their favourite habitat. Many families are carnivorous. Life histories of gastropods are often complicated with larval stages.

Lamellibranchia (*Pelecypoda* or *Bivalvia*)—Lamellibranchs form the second largest class of molluscs and include cockles, oysters, mussels and clams. The shell is composed of two valves hinged on the back by an elastic ligament, on account of which they are popularly known as Bivalves. Most of the forms are marine; a few families inhabit fresh water. In general, they are burrowing in habit, living half-buried in muddy or sandy bottoms; a number of forms are completely sedentary remaining attached to hard substrata by thread-like byssus of the foot or by one of their shell valves. A few forms burrow into submerged timbers, and commensal and parasitic types are also known. Some marine forms extend to a depth of 2,700 fathoms (4.94 km.). Life histories of bivalves pass through larval stages, which undergo remarkable changes before assuming adult characteristics.

Cephalopoda—This class includes cuttlefish, squids, octopods, nautilus and other allied forms. The name cephalopod is derived from the fact that the head and foot are merged into a single mass. At the anterior end of the head eight or ten arms, provided with a large number of suckers, are present in a circle enabling the animal to cling tenaciously to any object. Generally, the shell is degenerate and concealed within the body. The shell of nautilus is external, large and spirally coiled with numerous chambers of which the last in the series is occupied by the animal. A characteristic organ, the 'ink sac', opens into the rectum and contains a dark fluid which can be poured into the sea water, where it forms a cloud and serves as a means of concealment and escape from enemies. Cephalopods are marine animals; some are found in brackish water and a few are fossorial; most of them inhabit the open sea up to a depth of 2,600 fathoms (4.75 km.). They are extremely active and aggressive and prey on fish, crustaceans and other molluscs. Many of the deep sea forms are luminous. Life histories of cephalopods are simple, young ones resembling the adults on hatching [Encyclopaedia Britannica, XV, 674–77; Cooke, A.H., III, 1–459; Regan, 48–64; Thomson, 457–513; Pycraft, 102–47; Buchsbaum, 181–206; Annandale & Prashad, *Rec. Indian Mus.*, 1919, **16,** 241; Prashad, ibid., 1920, **19,** 165; 1921, **22,** 111, 137; 1925, **27,** 405; 1927, **29,** 283; 1933, **35,** 1; Comber, *J. Bombay nat. Hist. Soc.*, 1906, **17,** 207; Dalgliesh, ibid., 1907–08, **18,** 92; Ida Colthurst, ibid., 1928–29, **33,** 380, 552, 828; Patil, ibid., 1951–52, **50,** 549; 1952–53, **51,** 29; Rensch, ibid., 1955–56, **53,** 163; Satyamurthi, *Bull. Madras Govt. Mus., N.S.*, 1952 **1**(2), pt 6; 1956, **1**(2), pt 7].

Molluscan species important from the point of view of fisheries and those fished for shells and pearls are mentioned under FISH & FISHERIES (Wlth India—Raw Materials, IV, suppl.) and OYSTERS (Edible and Pearl) (Wlth India—Raw Materials, VII).

Molluscs as food—Among the edible gastropods, limpets (*Patellidae*) are collected for food in some parts of the Madras coast. The more common among them are *Cellana radiata* Born and an allied species.

The flesh of ear-shells (*Haliotidae*) is esteemed as food. *Haliotis* (*Haliotis*) *varia* Linn. is found attached to rocks and boulders at and below low tide level and seldom exceeds 38 mm. in length.

Among the top-shells (*Trochidae*), the flesh of *Trochus niloticus* Linn. and *T. stellatus* Gmelin is eaten in South India. The turban-shells (*Turbinidae*), *Turbo brunneus* Roding and *T. marmoratus* Linn. are, however, preferred. Large quantities of the button-shell, *Umbonium* (*Rotella*) *vestiarium* (Linn.), a trochid, are collected along the Bombay coast and eaten as a delicacy.

The flesh of the apple-snail, *Pila globosa* (Swainson) (*Pilidae*), is collected and eaten in several localities in Tanjore and Tirunelveli districts of Madras State. The snail is commonly found in lakes, tanks, marshes, ponds and paddy fields.

Horn-shells (*Cerithiidae*) are esteemed as wholesome food in the Philippines. The only species used as food in India is *Telescopicum telescopicum* Linn. found in abundance in the swamps of Gangetic, Krishna and Godavari deltas and also of the Konkan coast.

Two species of wing-shells (*Strombidae*), commonly collected for food, are *Strombus canarium* Linn. and scorpion-shell or five-fingered chank, *Lambis* (*Pterocera*) *lambis* (Linn.); the former is abundant in the shallows of the Palk Bay and the Gulf of Manaar; the latter is found on both the coasts and when fully grown measures 17.8 cm. in length and 8.9 cm. in width.

The naticids (*Naticidae*) occasionally collected for food are *Natica marochiensis* (Gmelin) and a few other species found on sandy shores.

Cowries (*Cypraeidae*), several species of which are common along Indian coasts, and tun-shell, *Tonna* (*Dolium*) *dolium* Linn. (*Amphiperatidae*), are only occasionally eaten.

The flesh of the sacred chank, *Turbinella pyrum* Lam. (*Turbinellidae*), is eaten dried, fried and in

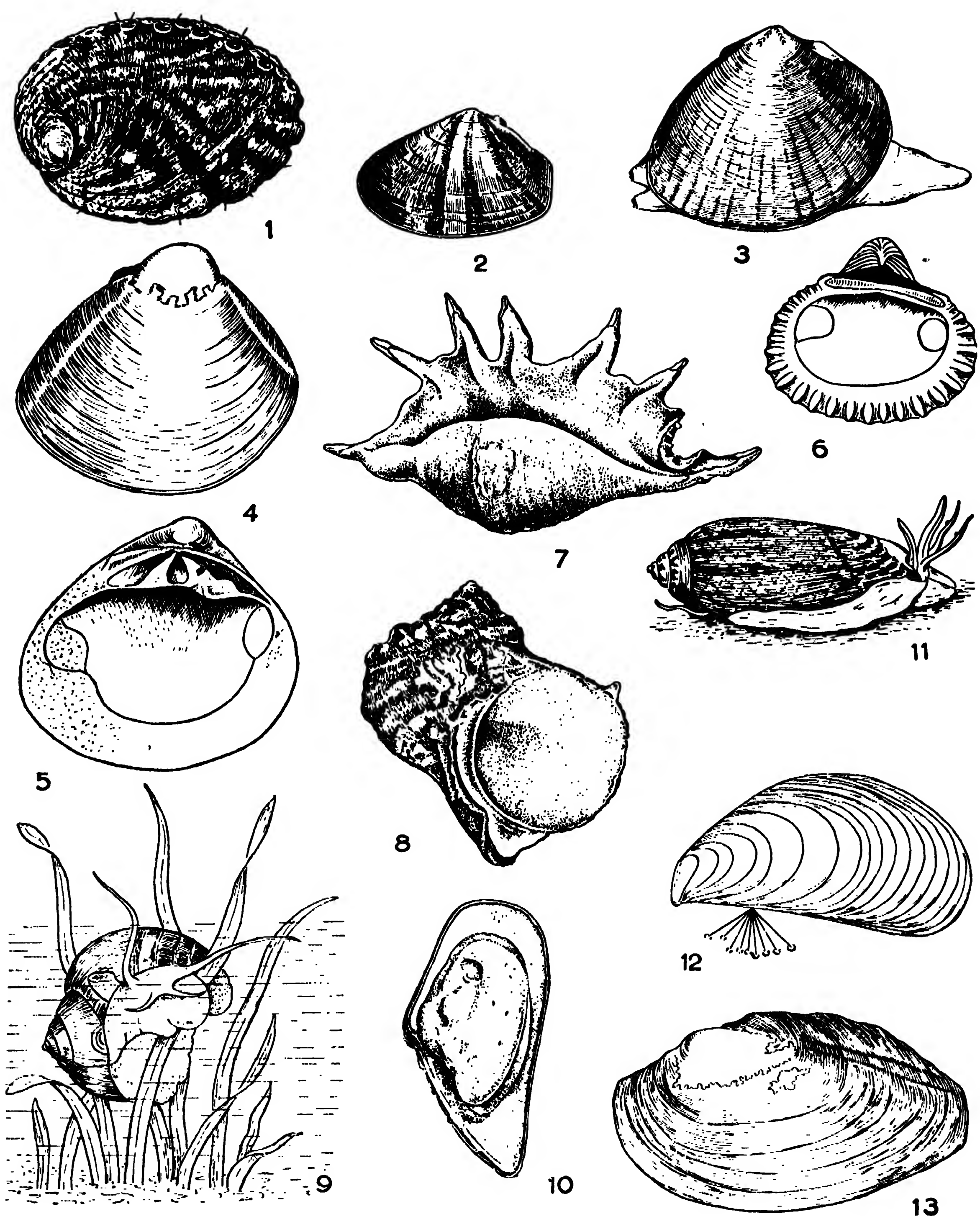


FIG. 147. EDIBLE GASTROPODS AND BIVALVES

1. *Haliotis* sp, ; 2 · *Donax scortum* 3. *Meretrix meretrix* ; 4 & 5. *Meretrix casta* ; 6. *Arca granosa* ; 7. *Lambis* sp. ; 8. *Turbo marmoratus* ; 9. *Pila globosa* ; 10. *Mytilus* sp. ; 11. *Oliva* sp. ; 12. *Mytilus viridis* ; 13. *Lamellidens marginalis*

curries in some coastal areas. The dog-chank consumed by fishermen in coastal areas is *Melongena* sp.; this is common at the mouths of backwaters. Among the knobbed chanks (*Fasciolariidae*), the species occasionally used as food is *Fusus* (*Hemifusus*) *pugilinus* (Born), which often grows to a large size.

The only species of true whelks (*Buccinidae*) utilized for food in India is *Cantharus* (*Cantharus*) *spiralis* (Gray); it is collected on the Konkan coast.

The purple shells (*Thaididae*) occasionally used as food are *Thais bufo* (Lam.), *T. rudolphi* (Lam.) and *T. carinifera* (Lam.); the first two grow to c. 5 cm. in length, and are collected and eaten in the coastal areas of Ramnad and Tirunelveli districts of Madras State. *T. carinifera* is collected in considerable quantities along the Bombay coast.

Of the volutids (*Volutidae*) the great melon-shell, *Melo indica* Gmelin, is utilized for food: adult melon-shell is globular in shape and attains a length of c. 20 cm. It is found all along the Indian coast but is particularly common in the Palk Bay at a depth of 5–6 fathoms (9–11 m.).

The olive shells (*Olividae*) extensively utilized as food by fishermen on the Coromandel coast belong to *Oliva* spp.; they are common on the east coast of India, but scarce on the west coast. The main collecting season is February–April. The catch is boiled in fresh water to extract the flesh to be used either in curry or fried in oil.

The imperial snail, *Ariophanta* sp. (*Zonitidae*), is occasionally eaten by tribes inhabiting teak forests in Cochin; it grows to c. 6.4 cm. in diam.

Bivalves most commonly utilized for food include edible oysters (*Ostreidae*), sea-mussels (*Mytilidae*) and clams (*Veneridae*).

All important commercial species of edible oysters belong to the genus *Crassostrea* Sacco and are in demand in cities like Bombay, Calcutta and Madras.

The backwater oyster, *Crassostrea madrasensis* (Preston), is commonly found to be confined to the southern regions on the west coast but widely distributed in all estuaries and backwaters of the east coast. It is good food, readily available from the vast natural resources. The rock oyster, *C. cucullata* (Born), occurs along both the coasts, but is more common on the rocky coasts of Bombay and Karwar. The disc oyster, *C. discoidea* (Gould), and *C. gryphoides* (Newton & Smith) are fished for food from the creeks of Kutch, Dwarka, Bombay, Ratnagiri, Jaytapur, Karwar, etc. on the west coast.

Two species of sea-mussels grow to a large size in Indian waters; they are the brown mussel, *Mytilus* sp. (Tam.—*Kallika, kadalka;* Mal.—*Chippi, muthuva*) and the green mussel, *Mytilus viridis* Linn. The former is consumed by fishing folk in the rocky coastal tracts of south Travancore and Tirunelveli district on the east coast. It is usually eaten after boiling with tapioca roots or rice. It may be sun-dried without loss of glycogen or protein; the dried material is tasty and keeps good for a number of days. The flesh of the green mussel is relished in Malabar and northern Travancore. The bearded weaving mussel, *Modiolus* (*Modiolus*) *barbatus* (Linn.) (Tam.—*Suran*), occurring in great abundance in the Palk Bay and pearl bank region of the Gulf of Manaar, is also used as food.

The more important clams used as food are: Backwater clams, *Meretrix meretrix* (Linn.) and *M. casta* Deshayes; cockle clams, *Gafrarium* (*Gafrarium*) *tumidum* Roding and *G.* (*Circe*) *divaricatum* Gmelin (Tam.—*Vari matti*); false clams, *Paphia malabarica* Dillwyn, *P. marmorata* (Reeve), *P. textile* Gmelin, *Katelysia* (*Eumarcia*) *opima* (Gmelin); and black clam, *Velorita cyprinoides* (Gray). *M. meretrix* attains a length of 74–75 mm. and a depth of 60–62 mm.; it occurs in extensive beds along Bombay, Alibag, Ratnagiri, Jaytapur, Karwar, Kodibag, etc. on the west coast, but is comparatively rare on the east coast. *M. casta* (av. length 35–40 mm. × 25–28 mm. depth) is collected in abundance from all estuaries and backwaters of both the coasts; it is nearly as important a food mollusc as edible oysters. *G. tumidum* inhabits the tidal mudflats and is plentiful in the Palk Bay and the Gulf of Manaar where it is greatly esteemed by shore dwellers. *G. divaricatum* is found along the Bombay coast. Clams are generally marketed alive; to remove the flesh, the shells are broken or the clams boiled in water for c. 20 min. *Paphia* spp. are found along both the coasts, but are particularly abundant in the vicinities of Karwar on the west coast. *K. opima* occurs under marine as well as estuarine conditions in all shallow water regions. *V. cyprinoides* is peculiar in its distribution in that the living forms are confined only to the west coast backwaters and estuaries, whereas its dead shells occur in sub-fossil deposits on the east coast.

The ribbed ark-shell, *Arca granosa* Linn. (*Arcidae*), is widely distributed in sandy backwaters and estuaries along the Indian coast; its flesh is red and though tough, it is considered to be

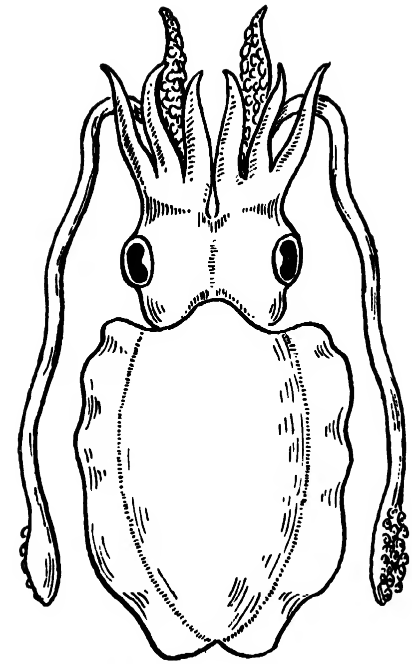


FIG. 148. SEPIA SP. (CUTTLEFISH)

nutritious. It seldom exceeds 53 mm. in length and 43 mm. in thickness. The true scallop, *Chlamys senatoria* Gmelin (*Pectinidae*), inhabits deep waters and is reported to possess a high food value. The false cockle, *Cardita bicolor* Lam. (*Carditidae*), is common on coarse sandy bottoms in shallow bays.

The freshwater mussels, *Lamellidens marginalis* (Lam.) and *Parreyssia* spp. (*Unionidae*), are widely distributed and used as food.

The wedge-shells or wedge clams, *Donax cuneatus* Linn. (Tam.—*Mural, vazhi matti*) and *D. scortum* Linn. (*Donacidae*), are greatly valued as food by fishing communities, specially in some parts of South India. *D. cuneatus* is abundant between tide marks at a short distance below low tide level, but never enters backwaters; it is plentiful on the east coast. The adult attains a length of *c.* 40 mm. *D. scortum* is much less common, but is bigger, attaining a length of *c.* 63 mm.

Mesodesma glabratum (Lam.) (*Mesodesmatidae*) is found in intertidal zones of oceanic islands and is occasionally used as food. The violet clam, *Mactra corbiculoides* Deshayes (*Mactridae*), is found in shallow bays on sandy shores; it is particularly common in the region of Adam's Bridge. *Cardium asiaticum* Bruguiere (*Cardiidae*), known as Asiatic cockle, is found on all sandy coasts; it attains a length of *c.* 51 mm.

Holy-water clams or giant clams, belonging to the genus *Tridacna* Bruguiere (*Tridacnidae*), are sometimes consumed as food; they are found on coral reefs, particularly in the Gulf of Manaar and on the Andaman coast.

Sanguinolaria (*Soletellina*) *diphos* (Gmelin) and *S.* (*Soletellina*) *atrata* Deshayes (*Garidae*) are sometimes eaten; the former is fairly common on the Coromandel coast and the latter on the Konkan coast. *S. diphos* grows to *c.* 127 mm. in length and is the bigger of the two.

The species of razor-shells (*Solenidae*) used as food are *Solen truncatus* Sowerby and *S. brevis* Hanley, common on the Bombay coast; they live buried at depths of 15–51 cm. in sandy bays as well as in deep waters and are 76–102 mm. in length.

The edible cephalopods found in Indian waters are not many; *Sepia aculeata* F. & d'Orb., *S. rostrata* (F. & d'Orb.), *S. rouxii* F. & d'Orb., and *Sepiella inermis* (F. & d'Orb.) among the cuttlefish, *Sepioteuthis arctipinnis* Gould, *Loligo indica* Pfeffer, *L. affinis* Koning, *L. hardwickii* Gray and *L. duvancelii* d'Orb. among the squids, and *Octopus herdmanii* (Hoyle), *O. hongkongensis* Hoyle, *O. octopodia* Hoyle, *O. favonia* Hoyle, *O. incertus* Hoyle and *O. rugosus* (Bosc) among the octopi are the cephalopods which are commonly utilized as food.

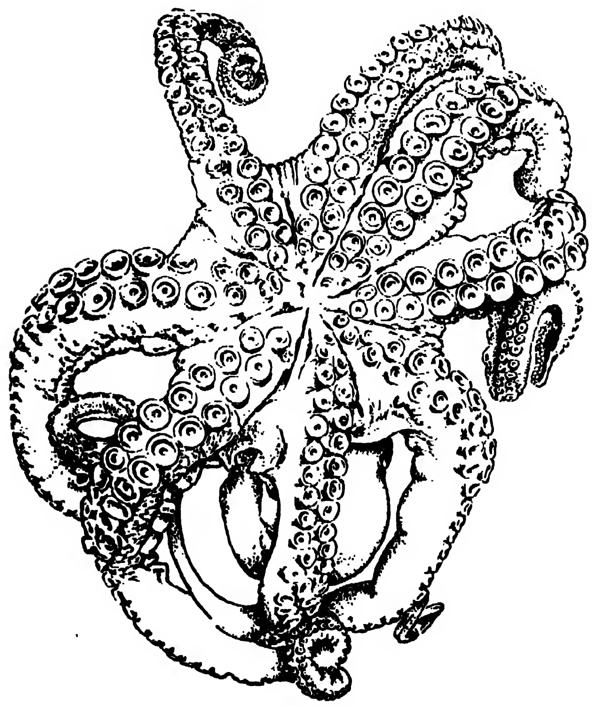


FIG 149. OCTOPUS SP.

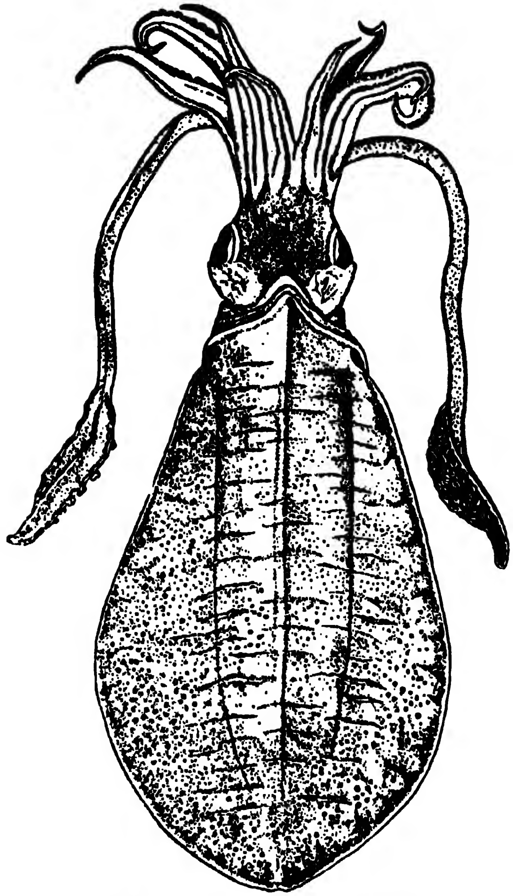


FIG. 150. SEPIOTEUTHIS ARCTIPINNIS

Preparation of molluscs for food—All molluscs are prepared suitably to the taste before they are consumed. The meats of mussels, oysters, clams and gastropods, in their fresh condition, are stewed or treated with spices and fried or made into curries. The flesh of squids is either baked or minced. When they occur in abundance, the clam meats, squids and the flesh of chanks are sun-dried and such products are prepared, as in the case of fresh ones, after softening them by soaking in water.

Table 1 gives the chemical composition of few important edible Indian molluscs.

Molluscs as food of marine life—Molluscs also serve as valuable food of various marine forms. The larvae of the bivalves and the young or the smaller species of adult gastropods, like pteropods, appear in such abundance in certain seasons that the zooplankton feeders among the commercial species of fish to a large extent depend upon them for their food. The bottom dwelling fish like the skates and the rays feed mostly on the bivalves and the gastropods. Whales and porpoises to a large extent subsist on shoals of squids and other cephalopods. Even in freshwater habitations a number of molluscan forms serve as food for fish life.

As bait—Cuttlefish, squids and octopods are cut into strips and used as efficient bait in hook-and-line fishing of various commercial species of fish on both the coasts of the country. In the south-eastern coastal villages bordering the Palk Bay octopods for bait are secured in specially devised traps for which the fingered chank shells are very largely used. Fishermen collect the bait sheltering within the shells.

TABLE 1—CHEMICAL COMPOSITION OF A FEW IMPORTANT EDIBLE INDIAN MOLLUSCS

Species	Edible portion	Moisture	Protein	Fat	Carbo-hydrates	Ash %	Ca %	P %	Iron mg./100 g.
Apple-snail (*Pila globosa*)[1]	..	74.1	10.5	0.6	12.4	2.4	0.87	0.12	
Sacred chank (*Turbinella pyrum*)[2]	3	67.5	24.84	0.82		1.84	0.13	0.09	2.71
Backwater clam (*Meretrix casta*)[3,4]	7.62–17.72	73.18–84.02	5.96–12.29	0.5–1.89		0.67–2.31	0.06–0.37	0.11–0.20	1.42–16.56
Backwater oyster (*Crassostrea madrasensis*)[3]†	5.03–17.36	76.67–85.04	5.72–13.31	1.36–3.07		0.52–2.06	0.04–0.40	0.10–0.21	2.53–29.63
Green mussel (*Mytilus viridis*)[1]	42.8	81.46	9.92	1.97		3.04	1.84	0.16	..
Freshwater mussel (*Lamellidens marginalis*)[5]		79.45	14.50	1.61	2.13	2.31	0.59	0.41	

[1] *Hlth Bull.*, No. 23, 1951, 52; [2] Venkataraman & Chari, *Curr. Sci.*, 1953, **22**, 22;
[3] Venkataraman & Chari, *Indian J. med. Res.*, 1951, **39**, 533; [4] Chari, ibid., 1948, **36**, 253;
[5] Mitra & Mittra, ibid., 1945, **33**, 91;
† On dry wt. basis.

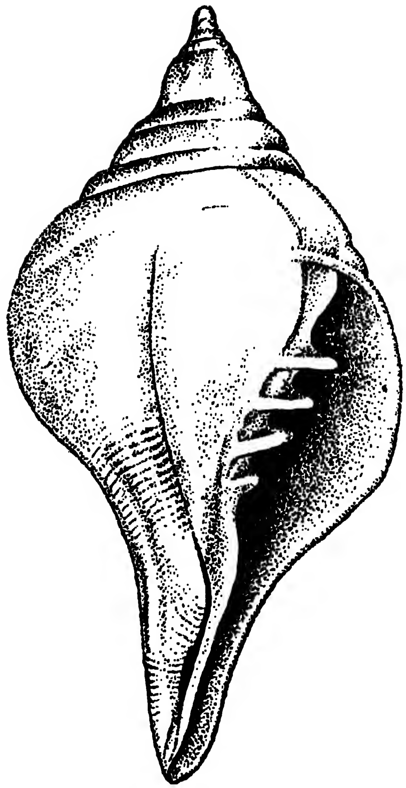


FIG. 151. TURBINELLA PYRUM

Mussels, clams and gastropods are also often used as fish bait.

Medicinal uses—The sacred chank, *Turbinella pyrum* (SANS.—*Sankha*; BENG.—*Sankh*; TAM.—*Sangu*) is widely used in the indigenous system of medicine. After burning, the residual lime is used for dyspepsia, piles, general debility, and some skin and lung diseases. Calxed shell or *bhasma* is used as demulcent and cardiac stimulant. The soft parts of the chank are used for spleen enlargement in Bengal. Cowries such as money cowrie, *Cypraea moneta* Linn. (SANS.—*Varatika*; HINDI & BENG.—*Cowrie*; BOMBAY & MADRAS—*Kavadi*), are also much used in medicine, more or less for similar purposes. The flesh of the apple snail, *Pila globosa*, is used for sore eyes in South India. Land-snails have also been used in medicine; the shell of *Achatina fulica* Ferussac (BOMBAY—*Nakhala*) (*Stenogyridae*) is used in the preparation of medicated oils.

Seed pearls produced by the windowpane oyster, *Placuna placenta* Linn. (*Anomiidae*), which are often misshapen and too soft for jewellery, are used in the treatment of eye diseases. The pearls produced by the black-lipped pearl-oyster, *Pinctada margaritifera* (Linn.) (*Pteriidae*) (SANS.—*Mukta*; HINDI—*Moti*; BOMBAY—*Moti*; MADRAS—*Muttu*), are used medicinally in the form of ash or *bhasma*. The flesh of the edible oysters, *Crassostrea madrasensis* and *C. gryphoides* (HINDI—*Sipi*; BENG.—*Jalasukti*, *jhinuk*; BOMBAY—*Kalu*), is acrid and used as demulcent. Seed pearls obtained from freshwater mussels are credited with invigorating properties. Large quantities of sea-mussels are utilized in the manufacture of vitamin products.

Cuttlefish bones of *Sepia* spp. (SANS.—*Samudraphena*; HINDI—*Samudrajhag*, *darya-kaf*) are used as antacid, astringent and sedative.

Ornaments and jewellery—Molluscan shells are extensively used in the manufacture of fancy goods and inlaid artware. The mother-of-pearl lining of the ear-shell, *Haliotis* (*Haliotis*) *striatus* Linn., is gorgeously coloured and is used in decorative inlaid work, lacquer work, handles for cutlery and trays. Top-shells of the genus *Trochus* Linn. and turban-shells of the genus *Turbo* Linn. are important commercially because of the thick and beautiful mother-of-pearl lining of their shells. The shells of *Trochus niloticus* and *Turbo marmoratus* are in great demand for the manufacture of pearl buttons, studs, brooches and other ornamental ware. The large pearly shell of *T. marmoratus* is employed by jewellers and lapidaries in Japan and India; it is also used in the ornamentation of screens, boxes and trays; the aquamarine work of Jaipur, in which the pearly shell is employed, is well known. The opercula of some *Turbo* species are stout, massive and plano-convex in shape; they are large (diam., *c.* 5 cm.) and heavy enough to be used as paper weights. Rings and brooches are also cut from the opercula of some *Turbo* species. *Trochus niloticus* and *Turbo marmoratus* have been fished in the waters of Mergui Archipelago and the Andaman and Nicobar Islands for the past several decades; they occur on coral reefs and rocks above the ten-fathom (18.3 m.) line around the islands.

The variegated shell of *Umbonium* (*Rotella*) *vestiarium* (*c.* 6.4 mm. across), varying in colour from pinkish white to brown, is used in the ornamentation of shell-boxes; this species is collected along the Bombay coast and millions of shells are exported to Europe.

The shells of *Strombus canarium* are made into finger rings and necklaces. Some species of cowries are used in ear-rings and necklaces and for ornamenting dresses, belts, shields, etc.

The shell of a species of *Triton* Montfort (*Tritonidae*) is used as a trumpet and as a musical instrument, most commonly in temples.

Helmet-shells (*Cassididae*) of the larger species of the genus *Cassis* Lam. are utilized in cameo-carving. The species found in Indian waters, commonly utilized for this purpose, are *Cassis* (*Cypraecassis*) *rufa* Linn. and *C.* (*Cassis*) *cornuta* Linn.; the shell substance consists of several layers, all differently coloured, and lends itself admirably for carving. The latter species is the largest and the heaviest among the Indian gastropods and is usually found at a depth of 8–10 fathoms (14.6–18.3 m.) on pearl banks in the Gulf of Manaar and around Laccadives. The shell weighs *c.* 2 kg. and is comparatively rare. The former species grows to *c.* 15 cm. in length and is of reddish tint; it is common in Laccadive waters.

Chank shells are used for bangles, beads, pendants, rings and a variety of other articles: the horny lid or the operculum is made into a paste for use in incense sticks or *dhup*. The shell of Indian chank, *Turbinella rapa* Lam., is used as a receptacle for oil in temples; it is also used as a bowl by sadhus.

Small specimens of banded shells and knobbed chanks, belonging to the species of *Fasciolaria* Lam., are strung together into necklaces. The spindle-shells of the genus *Fusus* Lam. are used by fishermen as lamps in fishing boats. The shells of gastropods of the genera *Cymbium* Rafinesque, *Dolium* Lam., *Pterocera* Lam. and *Murex* Linn. are used as lamp shades.

Because of their beauty of form and colour markings, molluscan shells have been favourite objects with curio collectors. Rare shells, like that of *Conus* spp., fetch extravagant prices; shells of *Melo* spp. are handsome. The utilization of cowries as currency and for bartering purposes till the early parts of the present century is well known, but has now only antiquarian interest. Small cowries and other gastropod shells of the genera *Trochus* Linn., *Mitra* Lam., *Haminea* Leach, *Nerita* Linn., etc. are commonly used in indoor games in India.

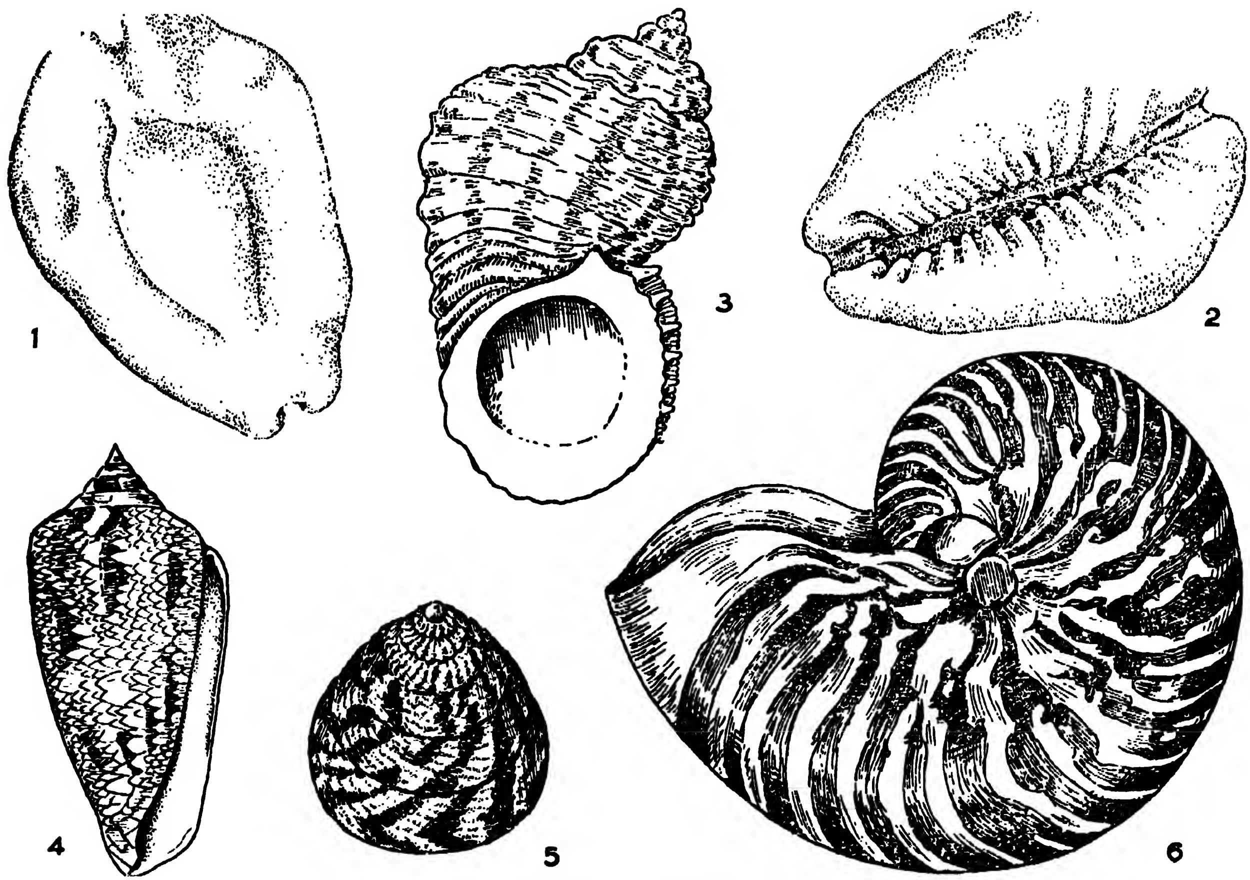


FIG. 152. ORNAMENTAL MOLLUSCAN SHELLS

1 & 2. *Cypraea moneta*; 3. *Turbo* sp.; 4. *Conus textile*; 5. *Trochus niloticus*; 6. *Nautilus* sp.

Among bivalves the shell of the windowpane oyster, *Placuna placenta*, is used for glazing windows and verandah roofs: the shell is peculiarly soft, and both in appearance and substance, it resembles mica, particularly when immature. Considerable quantities of pearls are produced by the windowpane oyster but they are of minor importance.

The common freshwater mussel, *Lamellidens marginalis,* produces pearls of fair quality in large numbers; they are collected and sold in South India; the pearls have a reddish tint and are less lustrous than those of marine oysters. Pearls of poor lustre are also reported from the green mussel, *Mytilus viridis,* from Sonapur backwaters.

Among cephalopods, shells of Pearly Nautilus (*Nautilidae*) are used in decorative ware, e.g. ash trays and incense-stick stands; they are discoidal in form and often reach 10-13 cm. in diam. They are thrown ashore during monsoon storms and fetch high prices.

The cuttlebone of *Sepia* spp. is used by cabinet makers and glaziers for polishing purposes; fine grade wood acquires a high polish when treated with cuttlebone. The collection of bones during the monsoon when cuttlefish drift ashore is a minor industry in some parts of the Indian coast. A dark brown pigment, called sepia, is obtained from the ink-sac of cuttlefish and related forms. It is extracted by boiling the material with caustic soda, filtering the extract and then adding hydrochloric acid for precipitating the colouring matter. It contains a black pigment, melanin (78%), and is used for imparting tone and background to photographs and art work.

Ink-sacs of squids, belonging to *Loligo* spp., are the source of an ink which is permanently black and is used chiefly in water-colour painting. The ink contains melanin and is extracted in a manner similar to sepia.

Lime manufacture—The production of lime from molluscan shells is an important industry in the coastal areas of India. Shells of various species of gastropods and more especially bivalves are gathered in large quantities from the surf-beaten sandy shores, estuaries and backwaters. The shells collected for the purpose include those of the genera *Triton* Montfort, *Strombus* Linn., *Lambis* Roding (=*Pterocera* Lam.), *Arca* Linn., *Nerita* Linn. and broken cowries. The shells of freshwater mussels and sea-mussels are also used for lime manufacture. Horn-shells (*Cerithiidae*), which lie exposed to the sun on the seashore in abundance, yield a good quality of lime. An almost inexhaustible quarry of cockle shell (*Arcidae, Cardiidae, Pectinidae* and *Solenidae*) lies near the village Jura, two miles (3.22 km.) from Ratnagiri, on the west coast of India. Other abundant sources of shells are the sub-fossil deposits of the Pulicat Lake area near Madras, Surla in Orissa, Vembanad Lake in Kerala and Kadalundi in Malabar. The chief species of these deposits belong to the genera, *Meretrix* Lam., *Velorita* Gray, *Arca* Linn., *Cardium* Linn., *Cardita* Bruguiere, *Pectonculus* Latr., *Turbinella* Lam., *Rapana* Schumacher, *Murex* Linn., *Natica* Scopoli, *Umbonium* Link. etc.

Lime produced by burning molluscan shells is of superior quality for use in masonry construction and white washing. It is used also as a fertilizer. The shells are directly used for the production of high grade cement at Kottayam, Kerala State.

Miscellaneous uses—Some of the finer shells, such as those belonging to the genera *Placuna* Bruguiere, *Spirula* Lam., *Dolium* Lam., and of cockles (chiefly *Cardiidae*), are used in the manufacture of tooth pastes. The shells are collected in Tuticorin and sent to Calcutta and Madras for this purpose. Waste shells of *Trochus* Linn. and *Turbo* Linn. and cuttlefish bones are used in tooth powders. In South Travancore, shells of the brown mussel, *Mytilus* sp., are used as manure for gardens and coconut farms. Sea-mussels are also considered useful as fertilizers for the soil.

Harmful molluscs—Marine borers belonging to the families *Pholadidae* and *Teredinidae* of *Bivalvia* cause considerable damage to underwater wooden construction, wooden sailing craft and floating timber, particularly in the tropics. The sea fishing industry which depends mainly on wooden catamarans and boats, is reported to suffer an annual loss of about a crore of rupees as a result of borer damage.

Martesia striata Linn. is a common burrowing pholad found along the coasts; it is also reported to bore into floating wood up to a depth of 17 m. in the sea. Several species of teredinids or shipworms belonging to the genera *Teredo* Linn. and *Bankia* Gray are particularly destructive. A few important among them are: *Teredo manni* (Wright), *T. diedrichseni* Roch, *Bankia carinata* Leach and *B. companuellata* Moll. Some common species of *Teredo* attain a length of 1 m. or more, with a diameter of c. 6.3 mm. They start burrowing in the wood when quite tiny and continue to live in the burrow.

Although the natural resistance of different timbers to borer attack varies, even the hardest wood is not immune and protection of underwater woodwork by metal sheathing or suitable coating compositions is essential. The common practice in India is to haul the vessel ashore and after careening and drying, to daub underwater parts with a mixture of lime, dammar and oil. Canoes and small boats are hauled ashore at frequent intervals and their bottoms smeared with rancid fish oil, foul enough to deter shipworm larvae. Paraffin soluble poisons are also used as preservatives. Temporary protection is secured by soaking in creosote. The use of concrete above wharves and docks reduces damage by shipworms.

The big land-snail, *Achatina fulica*, is a recognized pest of vegetable gardens. Land-slugs of the genus *Vaginula* Ferussac (*Veronicellidae*) are reported to be serious pests of vegetable crops like brinjal, tomato, chillies, cauliflower, cabbage, etc. in Andhra and Madras States during September–March; 2% metaldehyde in bran is reported to be effective in controlling the slugs. The bites of some species of cones (*Conidae*) and octopods are reported to be poisonous.

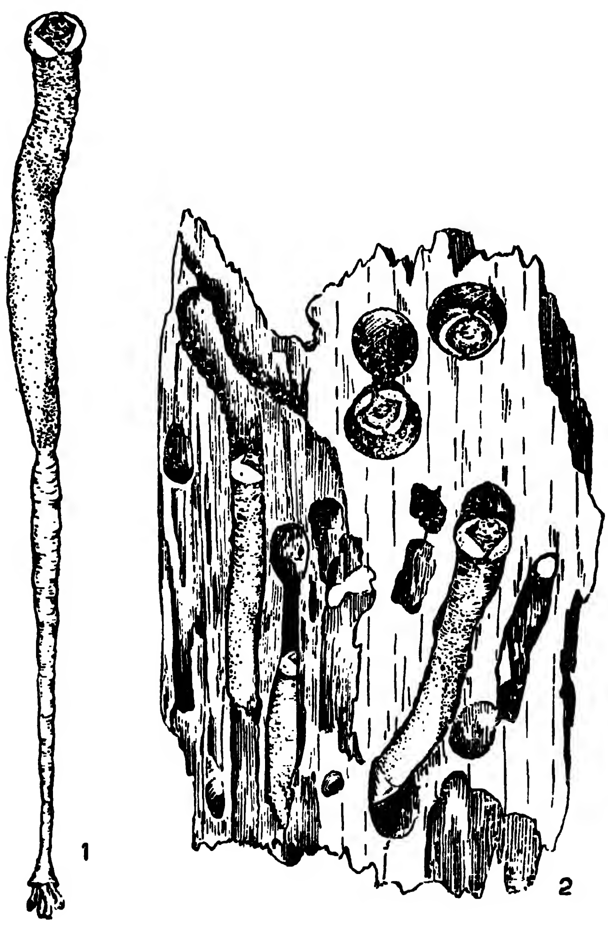


FIG. 153. WOOD INFESTED BY TEREDO SP.

Some genera of pulmonate aquatic snails act as intermediate hosts in the transmission of diseases to man and domestic animals. The diseases are caused by parasitic larvae of digenetic trematode worms which inhabit the digestive organs of snails. At a certain stage of their development, the parasites are left behind by the intermediate hosts on the grass and other herbage in flooded fields and in streams; sheep, goats and other cattle grazing in the fields and visiting the streams get infested and the flesh of these animals, unless properly cooked, is a source of infection for man. For a detailed account *see* PARASITIC WORMS (Wlth India–Raw Materials, VII) [Encyclopaedia Britannica, X, 69; Burkill, I, 511; II, 1537, 1612–13, 1682–83, 1764, 1993, 2089, 2134, 2188–90, 2205, 2267; Reese, 71–74, 79–82; Chandler, A.C., 199–253; Chopra, 544–50; Comber, *J. Bombay nat. Hist. Soc.*, 1905, **16,** 462; Hornell, ibid., 1948–49, **48,** 303, 543, 750; Jones, ibid., 1950–51, **49,** 519; Ray, ibid., 1950–51, **49,** 663; Palekar & Bal, ibid., 1955–56, **53,** 201; 1956–57, **54,** 962; Nair, ibid., 1956–57, **54,** 344; Hornell, *Bull. Dep. Fish. Madras*, 1916, **8,** 105; 1917, **11,** 1; Thapar, *Lucknow Univ. Stud.*, No. 3, 1936; Rao, *Sci. & Cult.*, 1941–42, **7,** 69; Pillai, *Proc. Indian Sci. Congr.*, 1948, 196; Venkataraman & Chari, *Curr. Sci.*, 1953, **22,** 22; Abraham, *J. zool. Soc. India*, 1953, **5,** 163; Rao & Ramadoss, ibid., 1953, **5,** 211; Ganapati & Nagabhushanam, *J. Timb. Dryers' & Pres. Ass. India*, 1955, **1**(1), 19; Secretary's Reports, ibid., 1958, **4**(2), 17; 1959, **5**(2), 34; Virabhadra Rao, *Souvenir, Central Marine Fisheries Research Station, Mandapam*, 1958, 55].

MOLYBDENUM ORES

Molybdenum is one of the scarce elements of the earth's crust and although a large number of minerals containing molybdenum have been described, only two, viz. Molybdenite and Wulfenite, are of commercial importance.

Molybdenite (MoS_2; sp. gr., 4.7–4.8; H., 1.0–1.5) is a soft, lead-grey mineral occurring as disseminated scales in igneous rocks, like granite, more usually in pegmatites and quartz veins associated with such rocks. In pegmatites and veins of deep-seated origin, the mineral may occur in relatively large patches;

in surface deposits, the mineral is present in the form of small scales. Molybdenite resembles graphite in form, colour and crystalline structure and it leaves on paper a bluish grey or greenish streak. It is heavier than graphite and can be readily distinguished from the latter by heating, when it gives off sulphur dioxide. In the presence of iron-bearing minerals and in acid solutions, molybdenite undergoes reduction to Molybdite or molybdite ochre ($Fe_2O_3.3MoO_3.8H_2O$) which is a pale yellow soft mineral occurring as silky fibres or earthy powder.

Wulfenite ($PbMoO_4$; sp. gr., 6.3–7.0; H., 3) is a greenish yellow to yellowish grey mineral with resinous or waxy lustre and white streaks. It is of secondary origin and occurs in massive granular forms or as tabular crystals in oxidized zones of deposits, containing molybdenite and galena.

Workable deposits of molybdenum ores occur chiefly in U.S.A. and also in Chile, Canada, Mexico, Norway and Japan. U.S.A. accounts for nearly 90% of the world production; production, in terms of Mo content, in 1958, was 21,500 metric tons. Molybdenite is sparsely distributed in India and the occurrences reported are of little economic importance.

Distribution in India

Andhra—Molybdenite occurs scattered in pegmatites intrusive into Khondalites at Kunavaram (17°34′:81°15′30″) in East Godavari dist. (Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 248).

Assam—Molybdenite is reported to occur in granite gneisses at Cherrapunji in Khasi hills (Coggin Brown & Dey, 239).

Bihar—Flakes of molybdenite have been occasionally noticed in metamorphic rocks and quartz veins in Chota Nagpur area. In Hazaribagh dist., molybdenite occurs at Mahabagh, Baragunda and Umri. It has also been detected in the copper ores of Rakha and Mosabani mines in Singhbhum dist. (Dunn, *Mem. geol. Surv. India*, 1941, **78,** 233).

Madras—In Madurai dist., molybdenite occurs in aplitic and pegmatitic rocks traversing the gneisses east of Karadikuttum (10°27′:77°26′). The mineral occurs also as disseminations in the nickeliferous pyrrhotite at Mangamalai in Thovala taluk, Kanyakumari dist. (Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 249; Coggin Brown & Dey, 239).

Mysore—In Kolar Gold Fields, molybdenite is found in a pegmatite at a depth of 2,500 ft. in the Balaghat lode, Ooregaum (Krishnan, *Rec. geol. Surv. India*, 1935, **70,** 427).

Rajasthan—Molybdenite has been reported in a pegmatite at Mandaoria (26°36′30″:74°57′30″) in Kishengarh dist. (Roy, *Mem. geol. Surv. India*, 1959, **86,** 324).

Beneficiation and Treatment

Molybdenum ores exploited in the various producing countries contain usually 1% or even less of molybdenite, and beneficiation techniques are applied for obtaining concentrates of the mineral. The mineral is separated from gangue by fine grinding and flotation using a mixture of pure oils, hydrocarbons and wetting agents. Primary flotation yields a concentrate containing up to 10% molybdenite; concentrates containing 60% molybdenite are obtained by further treatment.

Wulfenite may be concentrated comparatively easily as the mineral is heavy and is readily wetted. It is separated from gangue by gravity either by sluicing with water or by pneumatic concentration. The presence of heavy minerals, such as lead ores and vanadite, complicates the separation (Hampel, 272; Mellor, XI, 492).

The molybdenite concentrate is roasted in a current of air to obtain molybdenum trioxide (MoO_3), a white powder, which completely volatilizes at c. 700°. The oxide is converted into ferromolybdenum by treatment in an electric furnace with ferro-silicon, iron ore and aluminium in the presence of limestone and fluorspar. It is produced directly from the concentrate by fusion with varying proportions of coke, lime, scrap iron, pyrites, etc.

Preparation of metal—Metallic molybdenum is produced from the white crystalline sublimate of molybdenum trioxide by reduction with aluminium or carbon at high temperatures. The oxide may also be reduced to the metal by heating in a current of hydrogen at 1,000° in a tube furnace. In another process, the oxide is leached with dilute ammonia and the solution concentrated to obtain crystalline ammonium molybdate, which is subsequently reduced to the metal by hydrogen reduction.

Uses

Molybdenum in pure form (at. wt., 96; at. no., 42; sp. gr.^{20}, 10.2; m.p. 2,450°) is silver-white in appearance, and tough and malleable. It is not oxidized by air at ordinary temperatures, but burns when heated above 600° to form white molybdenum oxide. Molybdenum is used in the form of wire for filament supports, hooks, etc. in electric lamps and radio

valves, for electrodes in mercury vapour lamps and for winding electric resistance furnaces.

The principal use of molybdenum is in the production of alloy steels, for which purpose it is added in the form of ferro-molybdenum. About 90% of the ore is utilized for the production of ferro-molybdenum. It has been found that the addition of small amounts of molybdenum improves the hardenability of engineering alloy steels without affecting other desirable mechanical properties like machineability or forgeability. Alloy steels, containing molybdenum, require higher heat treatment, but they possess unusual toughness. Molybdenum also imparts resistance to corrosion, shock, fatigue and plastic deformation. In high-speed tool steels, tungsten has been successfully substituted by molybdenum to the extent of 50% or more. The molybdenum contents of some special steels are as follows: structural grades and steel for heat treated machine parts, 0.15–0.35%; tool steel and heat-resistant grades, up to 1.5%; corrosion-resistant stainless steels, up to 4% and high-speed tool steel, up to 8.5%.

Molybdenum salts are used as pigments in silk, woollen, leather and rubber industries, and for the production of glazes used in the ceramic industry. Molybdenum disulphide finds use as a lubricant. Some molybdenum compounds are used as catalysts for promoting chemical reactions. Ammonium molybdate is used in the identification of phosphate and arsenate radicals in chemical analyses.

Imports

India is deficient in molybdenum minerals and all requirements are met by imports. The imports of the metal and its base alloys during 1958, 1959 and 1960-61 were 4,415 lb. (val., Rs. 104,589), 4,654 lb. (val., Rs. 108,772) and 9,877 lb. (val., Rs. 174,927) respectively.

MOMORDICA Linn. (*Cucurbitaceae*)

A genus of annual or perennial climbers found in the tropics, chiefly in Africa. Six or seven species have been recorded in India, of which *M. charantia* (Bitter Gourd) is widely cultivated.

M. balsamina Linn. BALSAM APPLE

D.E.P., V, 256; Fl. Br. Ind., II, 617; Chakravarty, *Rec. bot. Surv. India*, 1959, **17**(1), 90.

HINDI—*Mokha*.

A monoecious climber found in the Punjab, western U.P., Rajasthan and Saurashtra, up to an altitude of 300 m. Leaves orbicular, glabrous, palmately 3–5 lobed; flowers yellow, solitary; fruits tuberculate, 2.0–7.0 cm. long, broadly ovoid, narrowed at both ends; seeds grey, ellipsoid, compressed, slightly verrucose.

Tender fruits of the plant are eaten as vegetable in stew or are pickled; they are used also for flavouring food dishes. Leaves and stems are used as camel fodder (Burkill, II, 1485; Tothill, 685).

The plant is considered stomachic and tonic. The fruit contains a cathartic principle, momordicin, which appears to be identical with elaterin. A liniment prepared by infusing the fruit, after removing the seeds, in olive or almond oil is used as a local application for chapped hands, burns, haemorrhoids, etc. Mashed fruit is used as poultice (Dalziel, 62; Kirt. & Basu, II, 1133; Watt & Breyer-Brandwijk, 179; U.S.D., 1955, 1758).

The bitter constituents present in the roots are chemically different from the cucurbitacins usually found in other genera of *Cucurbitaceae*. The seeds yield c. 40% of a fatty oil ($n_D^{40°}$, 1.5017; iod. val., 139; sap. val., 189) containing c. 50% of conjugated trienoic acid. The colouring matter present in the arils is lycopene, while that present in fruits is lutein; flowers contain carotene (Rehm *et al., J. Sci. Fd Agric.*, 1957, **8**, 679; Earle *et al., J. Amer. Oil Chem. Soc.*, 1959, **36**, 304; Palmer, 86, 72; Karrer & Jucker, 76).

M. charantia Linn. BITTER GOURD, CARILLA FRUIT

D.E.P., V, 256; Fl. Br. Ind., II, 616; Chakravarty, *Rec. bot. Surv. India*, 1959, **17**(1), 88.

HINDI—*Karela, kareli*; BENG.—*Karela*; MAR.—*Karle*; TAM.—*Pakal, pavakka*; KAN.—*Hagal*; MAL.—*Kaippa, kaippavalli*.

A monoecious climber found throughout India, often under cultivation, up to an altitude of 1,500 m. Stem slender, more or less pubescent; leaves sub-orbicular, 5–7 lobed, pubescent or sub-glabrous; flowers yellow, solitary; fruits 5.0–25.0 cm. long, pendulous, fusiform, beaked, ribbed with numerous tubercles; seeds brownish, 13.0–16.0 mm. long, compressed, embedded in red pulp.

The plant is cultivated throughout India as a vegetable crop. Two types are grown in N. India, the hot season or *Jethuya* and the rainy season or *Baramasiya*; the latter bears fruits nearly throughout the year. They differ in habit of growth, in size and shape of fruits and the period of maturation.

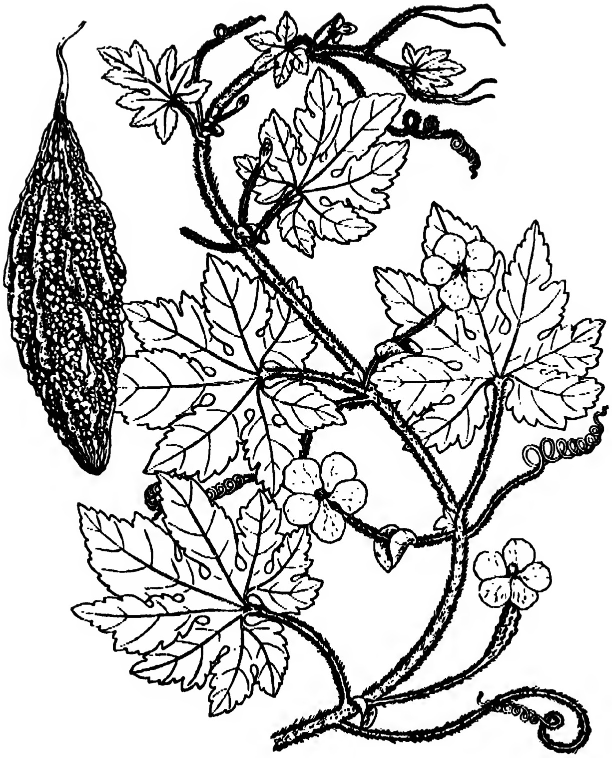


FIG. 151. MOMORDICA CHARANTIA—FLOWERING BRANCH & FRUIT

In S. India, 9 types which breed true for their economic characters have been selected for cultivation; they yield fruits which differ in size, colour and surface characters. Crossing among them has resulted in a few hybrids, some yielding large fruits with thick flesh and showing hybrid vigour (Firminger, 152; Gollan, 89; Purewal, 70; Aiyadurai, *Madras agric. J.*, 1951, **38,** 245).

The plant is commonly cultivated during the warm season of the year. In the hills, a summer crop is sown during April to July, while two crops are generally taken in the plains. The hot season or early crop is sown between March and April and is often grown without support; the rainy season crop is sown in June–July and is trained on supports. The seeds are sown in lines 2 ft. apart in well-prepared and manured beds or in small pits. Two or three seeds are planted in each pit but only one plant is retained after germination. The plants are watered once or twice a week during the dry weather. They begin to flower 30–35 days after sowing and fruits become ready for gathering 15–20 days later. The yield of fruits varies from 70 to 150 md. per acre (Gollan, 89; Firminger, 152; Purewal, *Farm. Bull. Indian Coun. agric. Res.*, No. 36, 1957, 93; Purewal, 70; Aiyadurai, loc. cit.).

Bitter gourd is affected by fruit-rot [*Pythium aphanidermatum* (Eds.) Fitz.] during the rainy season and leaf-spot (*Cercospora momordicae* McRae). Fruit-rot is controlled by spraying plants with Bordeaux mixture or cheshunt mixture. A common pest of bitter gourd is the fruit fly, *Dacus cucurbitae* Coq., which deposits eggs inside the flesh of the fruit. Spraying with solutions of nicotine sulphate (0.1%), Endrin (0.02%) or Parathion (0.025%) affords control. In some areas *Epilachna* beetle causes serious damage in September and October; it is controlled by spraying plants with calcium arsenate mixed with slaked lime. *Leptoglossus membranaceus* Fabr. attacks the stems, leaves and fruits and causes wilt; spraying in the early stages with gamma BHC (1.3% or 3.0%) affords effective control [Singh & Singh, *Sci. & Cult.*, 1952–53, **18,** 489; *Indian J. agric. Sci.*, 1950, **20,** 126; Srinivasan, *Indian Fmg, N.S.*, 1959–60, **9**(9), 8; Aiyadurai, loc. cit.; Fernando, *Trop. Agriculturist*, 1957, **113,** 107].

The fruit though bitter is wholesome and esteemed as vegetable when young; it may be sliced and preserved after drying for use in the off-season. The fruit is also pickled. It is often used as a flavouring for food preparations. The seed mass of the ripe fruit is used as condiment. The bitterness is reduced by steeping the fruit in salt water and cooking after removing the skin. Bitter gourd can be held in cold storage for 4 weeks at 32–35°F. and 85–90% R.H. (Aiyadurai, loc. cit.; Nadkarni, I, 806; Porterfield, *Econ. Bot.*, 1951, **5,** 3; *Bull. cent. Fd technol. Res. Inst., Mysore*, 1954–55, **4,** 215).

Analysis of the fruit (from types yielding small-sized fruits) gave the following values: moisture, 83.2; protein, 2.9; fat, 1.0; carbohydrates, 9.8; fibre, 1.7; and mineral matter, 1.4%: calcium, 50; phosphorus, 140; and iron, 9.4 mg./100 g.; carotene (as vitamin A), 210 i.u.; thiamine, 72 μg.; nicotinic acid, 0.5 mg.; riboflavin, 90 μg.; and ascorbic acid, 88 mg./100 g. Copper (traces) and potassium (282 mg./100 g.) are present. Bitter gourd is a good source of ascorbic acid and values up to 188 mg./100 g. have been reported in fresh tender fruit; ripe yellow fruit contains about half as much ascorbic acid. The ascorbic acid is retained by the green fruit during storage; if stored after ripening, considerable loss of ascorbic acid occurs. Slices of tender fruit lose c. 80% ascorbic acid on drying in the sun; c. 40% is lost during the cooking of fresh fruit.

Cooking destroys *c.* 40% of thiamine also (*Hlth Bull.*, No. 23, 1956, 36; Pain & Banerjee, *Indian J. med. Res.*, 1956, **44,** 749; Bagchi & Chowdhury, *Ann. Biochem.*, 1949, **9,** 107; Siddappa, *Indian J. agric. Sci.*, 1943, **13,** 639; Tewari, *Ann. Biochem.*, 1959, **19,** 191; Ahmad *et al.*, ibid., 1948, **8,** 89).

The fruit contains ascorbigen, a bound form of ascorbic acid released by heating with water in an atmosphere of carbon dioxide or nitrogen. Large sized fruits, borne by certain types of *M. charantia*, are richer in ascorbigen than small fruits borne by other cultivated types (Bose & Guha, *Sci. & Cult.*, 1959-60, **25,** 387).

The free amino acids present in the fruit are: aspartic acid, serine, glutamic acid, threonine, alanine, γ-amino butyric acid and pipecolic acid. The green fruit contains luteolin. Carotene is the principal pigment of carpels, while lycopene characterizes the red aril (Rao *et al.*, *J. sci. industr. Res.*, 1956, **15C,** 39; Ganju & Puri, *Indian J. med. Res.*, 1959, **47,** 563; Palmer, 76).

Tender shoots and leaves of the plant are also used as vegetable in India; they are used as flavouring in Java and Philippines. The leaves are a good source of calcium, carotene, riboflavin and ascorbic acid. Analysis of tender leaves (from Philippines) gave the following values: moisture, 82.5; nitrogen, 1.042; ether extr., 0.47; crude fibre, 1.8; and ash, 2.61%; calcium, 297.0; phosphorus, 53.0; iron, 3.27; carotene, 5.57; thiamine, 0.14; riboflavin, 0.55; niacin, 1.85; and ascorbic acid, 210.0 mg./100 g. (Burkill, II, 1485; Intengan *et al.*, *Philipp. J. Sci.*, 1954, **83,** 192, 208, 215).

The seeds yield (26.5%) a clear, reddish brown, semi-drying oil with the following characteristics: $d^{10°}$, 0.9958; $n_D^{27°}$, 1.4984; acid val., 3.4; sap. val., 184.1; iod. val. (Wijs), 120.4; diene val. (Ellis & Jones), 70.6; and unsapon. matter, 0.7%. The component fatty acids of the oil are: α-elaeostearic, 46.7; linoleic, 7.7; oleic, 15.8; and stearic, 29.8%. The oil is edible. It may be used in the paint and varnish industry as such or after segregation into suitable fractions by solvent treatment. Films of oil develop a wrinkled finish when exposed to air (Verma & Aggarwal, *J. Indian chem. Soc.*, 1956, **33,** 357; Chakrabarty *et al.*, *Naturwissenschaften*, 1955, **42,** 344; Airan, *Proc. Symp. Indian Oils & Fats & their Util.*, Nat. Chem. Lab., Poona, 1951, 256).

The seed cake left after the extraction of oil contains 13.4% of total proteins, from which an albumin (6.1%), a globulin (6.1%) and a glutelin (1.2%) have been separated. The proteins are especially rich in essential amino acids. The distribution of nitrogen in the proteins is as follows: *albumin* (N, 14.5; S, 0.967%)—amide N, 2.35; humin N, 0.07; diamino N (arginine, 50.55; histidine, 15.76; cystine, 1.07; and lysine, 19.92), 87.30; monoamino N, 7.5; and nonamino N, 3.89%; *globulin*—amide N, 3.89; humin N, 0.06; diamino N (arginine, 49.93; histidine, 14.45; cystine, 1.40; lysine, 21.93), 87.71; monoamino N, 7.2; and nonamino N, 3.17% (Airan & Ghatge, *Indian J. agric. Sci.*, 1951, **21,** 63; *Chem. Abstr.*, 1955, **49,** 5005).

FIG. 155. SEEDS OF MOMORDICA CHARANTIA AND OF M. DIOICA

The fruits and leaves of the plant contain two alkaloids, one of them being momordicine. Roots are also bitter; the bitter principles are different from cucurbitacins which occur in other genera of *Cucurbitaceae*. The plant is reported to contain a glucoside, a saponin-like substance, a resin with an unpleasant taste, an aromatic volatile oil and a mucilage. The seeds contain an alkaloid (m.p. 236°) and an anthelmintic principle in the germ; they also contain urease (Quisumbing, 945–46; Rivera, *Amer. J. Pharm.*, 1941, **113,** 281; Rehm *et al.*, *J. Sci. Fd Agric.*, 1957, **8,** 679; Rehm & Wessels, ibid., 1957, **8,** 687; Airan & Ghatge, *Curr. Sci.*, 1950, **19,** 19; *Chem.*

Abstr., 1930, **24,** 684; Nath & Ullah, *Ann. Biochem.*, 1956, **16,** 89).

The fruits are considered tonic, stomachic, carminative and cooling; they are used in rheumatism, gout and diseases of liver and spleen. The fruits of uncultivated forms are used as febrifuge. In Brazil, the seeds are used as anthelmintic; an alcoholic extract of the plant is used as a stomachic against colic and fever. The fruits, leaves and roots have long been used in India as a folk remedy for diabetes mellitus; they are reported to be used for similar purposes also in Puerto Rico. Oral administration of fresh fruit juice (dose, 6 c.c./kg. body wt.) lowered the blood sugar level in normal and alloxan-diabetic rabbits, but it proved toxic: the juice appears to be also abortifacient. However, the possibility of separating a non-toxic hypoglycaemic factor cannot be ruled out. Oral administration of alcoholic extracts of the plant to some diabetic patients did not produce any hypoglycaemic action (Kirt. & Basu, II, 1131; Nadkarni, I, 806; *Chem. Abstr.*, 1945, **39,** 2623; Sharma *et al.*, *Indian J. med. Res.*, 1960, **48,** 471; U.S.D., 1955, 1758; Rivera, *Amer. J. Pharm.*, 1942, **114,** 72).

M. cochinchinensis Spreng.

D.E.P., V, 257; Fl. Br. Ind., II, 618; Chakravarty, *Rec. bot. Surv. India*, 1959, **17**(1), 95; Kirt. & Basu, Pl. 455A.

Hindi—*Gulkakra, gangerua*; Beng.—*Gol-kakara, kakrol*; Tel.—*Adavi kakara.*

A perennial, monoecious climber with tuberous roots found commonly in Assam, Bengal, S. India and Andaman Islands. Stems glabrous; leaves suborbicular, deeply 3-5 lobed, glabrous: flowers white or pale yellow; fruit ovoid, 10–15.0 cm. long, pointed, densely aculeate; seeds ovoid, 26-28 mm. long, compressed, sculptured on both sides.

The tender fruits of the plant are esteemed as vegetable. Young leafy shoots are cooked and eaten in Bali and Philippines. Analysis of fruit gave the following values: moisture, 84.09; protein, 2.61; fat, 0.66; carbohydrates, 5.69; crude fibre, 5.93; and mineral matter, 1.02%: calcium, 21; phosphorus, 148; and iron, 2.59 mg./100 g. The fruit is a rich source of ascorbic acid; small sized fruits borne by types cultivated in the plains contain more ascorbic acid (*c.* 247 mg./100 g.) than those of types growing in hills and yielding large sized fruits. Ascorbigen is also present (Burkill, II, 1486; Mitra, *J. Indian chem. Soc.*, 1938, **15,** 623; Mitra *et al.*, ibid., 1940 **17,** 247; Bose & Guha, *Sci. & Cult.*, 1959 60, **25,** 387).

The seeds (av. wt., 3.1 g.) yield *c.* 29% of a pale green fat, which on exposure to air becomes pale yellow. It has an unpleasant penetrating odour and the following characteristics: m.p. 28-32°; $n^{40°}$, 1.496; sap. val., 185.2; acid val., 1.9; iod. val., 23.4; an unsapon. matter, trace. It is used as an illuminant in Indo-China; it may be used in admixture with drying oils in the formulation of paints and varnishes (*Kew Bull.*, 1920, 6; Burkill, II, 1487).

The roots contain a triterpenoid saponin, which on hydrolysis yields oleanolic acid and fucose, glucuronic acid and arabinose. Alcoholic extracts yield a sterol, named bessisterol ($C_{29}H_{48}O$. $\frac{1}{2}H_2O$, m.p. 175°), which is identical with spinasterol (Enslin *et al.*, *J. Sci. Fd Agric.*, 1957, **8,** 673; *Chem. Abstr.*, 1956, **50,** 188; 1937, **31,** 8542; Thorpe, VIII, 230).

The seeds of the plant are used as aperient and in the treatment of ulcers, sores and obstructions of liver and spleen. Fruits and leaves are used in external application for lumbago, ulceration and fracture of bones. In Hong-Kong, the plants are reported to be used as an alterative bitter drug in place of *Strychnos* (Burkill, II, 1486; Brown, 1946, III, 399; Rama Rao, 187; Dymock, Warden & Hooper, II, 77).

M. dioica Roxb. ex Willd.

D.E.P., V, 258; Fl. Br. Ind., II, 617; Chakravarty, *Rec. bot. Surv. India*, 1959, **17** (1), 91.

Hindi—*Kaksa, golkandra*; Beng.—*Ban-karela*; Mar.—*Kartoli*; Tel.—*Agakara*; Tam.—*Tholoopavai, paluppakai*; Kan.—*Karlikai.*

Assam—*Bhatkarela*; Punjab—*Kakaura, kirara, dhar karela.*

A perennial, dioecious climber with tuberous roots found throughout India from Himalayas to Ceylon, up to an altitude of 1,500 m. Stems glabrous; leaves broadly ovate, entire, deeply 3–5 lobed: flowers solitary, yellow; fruits ovoid or ellipsoidal, 2.5-6.3 cm. long, shortly beaked, densely echinate with soft spines; seeds slightly compressed, 6.0–7.0 mm. long, irregularly corrugated.

The plant is sometimes found growing wild and is common in hedges. It is often cultivated for its fruits which are used as vegetable. It flowers during the hot and cold seasons in S. India. The fruits, like those of *M. charantia*, are susceptible to fruit-rot, caused by

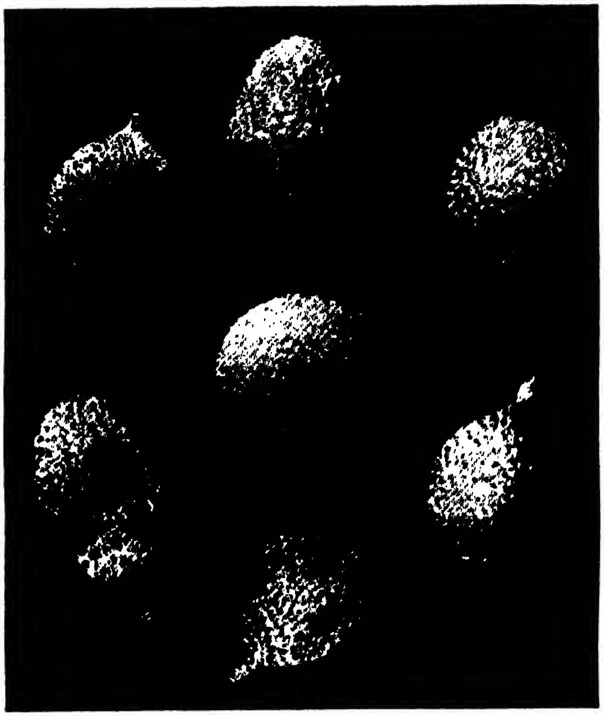


FIG. 156. MOMORDICA DIOICA—FRUITS

Pythium aphanidermatum (Eds.) Fitz. (Haines, III, 395; Sharma & Asthana, *Sci. & Cult.*, 1957-58, **23**, 435).

Analysis of the edible portion of the fruit gave the following values: moisture, 84.1; protein, 3.1; ether extr., 0.97; carbohydrates, 7.7; fibre, 2.97; and ash, 1.1%: iron, 4.6 mg.; calcium, 33 mg.; phosphorus, 42 mg.; carotene (as vitamin A), 2,700 i.u.; thiamine, 45.2 μg.; riboflavin, 176.1 μg.; and niacin, 0.59 mg./100 g. The fruit is rich in ascorbic acid (275.1 mg./100 g.). It contains iodine, 0.7 μg./100 g. [*Rep. Dep. Nutr. Govt. Bombay*, 1957, 24; Naik *et al.*, *J. Univ. Bombay, N.S.*, 1951, **19A**(29), 51; Iodine Content of Foods, 77].

The seed kernels, on extraction with carbon tetrachloride, yield 33.5% of a dark brown, semi-drying oil with the following characteristics: n^{40°, 1.4945; sap. val., 189.5; iod. val. (Wijs), 114.0; unsapon. matter, 0.9%; and free fatty acids (as oleic), 1.4%. The component fatty acids of the oil are: saturated acids, 27.1; oleic, 9.2; linoleic, 8.8; and conjugated triene (as α-elaeostearic), 54.9%. The oil may be used as such or after segregation into suitable fractions, as a drying oil in the paint and varnish industry (Chakrabarty *et al.*, *Naturwissenschaften*, 1956, **43**, 523).

The roots, which often weigh 1 lb. or even more, are astringent and contain traces of an alkaloid. The roots of the female plant are larger than those of the male and are preferred for medicinal use. They are applied in bleeding piles, bowel affections and urinary complaints. The root is pasted and applied over the body as a sedative in fevers (Dymock, Warden & Hooper, II, 75; Kirt. & Basu, II, 1135).

***M. tuberosa** (Roxb.) Cogn. syn. *M. cymbalaria* Fenzl ex Naud.

D.E.P., V, 258; Fl. Br. Ind., II, 618.

MAR.—*Kadavanchi*; TAM.—*Athalaikai*; MAL.—*Kattupaval.*

FIG. 157. MOMORDICA TUBEROSA—FLOWERING BRANCH, FRUIT AND TUBER

* This species has been transferred by Chakravarty to *Luffa* on account of the ribbed nature of the fruits, absence of cystoliths on the lower surface of leaves and absence of foliaceous bracts [*Rec. bot. Surv. India*, 1959, **17**(1), 81].

A perennial, monoecious, trailing plant with large turnip-shaped tuberous rootstock found in Deccan and Carnatic, southwards to Tirunelveli in Madras. Stem slender, 5-angled; leaves 5 7-angled; flowers white or yellow: male flowers in short racemes, female flowers solitary, long-peduncled; fruit pyriform or fusiform, 8-ribbed, 1.8–4.0 cm. long.

This plant occurs mostly in bushes along the banks of water courses and in hedges. It is not cultivated. Tender fruits are gathered from November to January and used as vegetable; it is also preserved in the form of sun-dried chips or after pickling. The roots are reported to be abortifacient: they contain a bitter glycoside and a yellow acid resin with acrid properties (Chandrasekhara Ayyar & Sundararaj, *Madras agric. J.*, 1945, **33**, 127; Dymock, Warden & Hooper, II, 80).

MONAZITE

The mineral Monazite (sp. gr., 5.25; H., 5.5) consists essentially of phosphates of cerium and few other rare earth metals; thorium is usually present. The mineral is widely distributed as an accessory constituent of Archaean or pre-Cambrian crystalline rocks, such as granites, diorites, gneisses and pegmatites. By powdering the rocks and washing away the lighter minerals, a heavy fraction containing minerals like monazite, ilmenite, rutile, magnetite, zircon, garnet, etc. can be separated. This separation takes place naturally during the washing down by rain and rivers of weathered and disintegrated rocks and under certain conditions monazite in the form of rounded water-worn grains occurs as accumulations in beds of streams and beach placers in several parts of the world. Old sand dunes near sea coasts sometimes contain monazite; such wind-borne deposits are occasionally cemented into compact masses by infiltrated carbonate of lime.

Monazite occurs either as flattened monoclinic crystals or as small rounded translucent grains varying in colour from pale yellow or greenish brown to dark reddish brown. It usually contains: rare earth oxides, 55–60% and thorium, 8 9%. A variety, known as Green Monazite or Cheralite, contains less of rare earth oxides and more thorium oxide (29–33%) and uranium oxide (4–6%).

Extensive deposits of monazite sand occur in India, Brazil, and North and South Carolina (U.S.A.); sizeable deposits are found also in Ceylon, Japan, Australia, Madagascar, South Africa, Canada, and Florida in U.S.A. The composition of concentrates from some of the important monazite deposits of the world are given in Table 1.

Distribution in India

The major monazite sand spreads are found at various sites on the Malabar (Kerala State) and Coromandel (Madras State) coasts. Occurrences of ilmenite containing variable percentages of monazite are found in several localities along the coastal region, from Cape Comorin to Narmada estuary on the west and from Tirunelveli to beyond the Mahanadi on the east. Large deposits of detrital monazite, capping the tops of certain plateaus, occur in Bihar and West Bengal. Besides these, monazite occurs in pegmatites in various inland parts of the country.

According to surveys conducted by the Department of Atomic Energy, there are at least 12 major monazite concentrations in India and provisional estimates place the total reserves at 2 million tons, of which Kerala deposits alone account for 1.5 million tons (Wadia, *J. sci. industr. Res.*, 1956, **15A**, 162; *East. Met. Rev.*, 1958–59, **11**, 126).

Andhra—Black sand, containing 0.14–8.0% monazite, occurs in patches along the coast extending from 13°33′ N (Nellore dist.) to 19°N (Srikakulam dist.). The patches vary in length from a few feet to a few miles and from 50 ft. to 2,000 ft. in width. Rich concentrates are confined to the northern side of the

TABLE 1—COMPOSITION OF MONAZITE CONCENTRATES*
(Figures give percent composition)

	India	Brazil	U.S.A. (Florida)	South Africa	Madagascar
Thoria	8.88	6.50	3.10	5.90	8.75
Ceria	28.46	26.80	40.7	24.90	23.20
Rare earth oxides other than ceria	30.91	32.40		21.51	23.00
Phosphorus pentoxide	27.03	26.00	19.30	27.00	20.00
Uranium oxide	0.35	0.17	0.47	0.12	0.41
Ferric oxide	0.32	0.51	4.47	4.50	..
Titanium oxide	0.36	1.75	..	0.42	2.20
Silica	1.00	2.20	8.30	3.30	6.70

* Sethna & Fareeduddin, *Symposium on Rare Metals held in Bombay from December 1 3, 1957*, organized by UNESCO, Atomic Energy Establishment and Indian Inst. of Metals, 68.

confluences of Vamsadhara, Nagavali and Vasishta rivers with Godavari and to either side of the confluence of Vainateyam with Godavari. Monazite occurs also on the beach *c.* 20 miles north of the mouth of Krishna river; the depth of the deposit varies from 3 ft. to 8 ft. Coastal sand dunes in the region also contain monazite (Mahadevan, *Proc. Second United Nations Intern. Conf. Peaceful Uses of Atomic Energy*, Geneva, 1958, **2**, 716).

The reserves of monazite in the beach sands between Bhimilipatam to Polavaram have been estimated at 8,000 tons. Black sands occurring between Dibbalapalem and Bhimilipatam contain on an average 3% monazite; the estimated quantity of mineral up to a depth of 5 ft. is 3,100 tons (*Indian Ceram.*, 1954-55, **1**, 347; Mahadevan & Rao, *Curr. Sci.*, 1950, **19**, 48).

Bihar & West Bengal—Placer deposits of monazite associated with ilmenite, rutile, sillimanite, columbite-tantalite and magnetite have been located in the Ranchi-Purulia area and in the adjoining districts of Bihar and West Bengal. The deposit at Katahaldih (23°27′:86°13′), 12 miles north west of Purulia town, covers *c.* 130 sq. miles. The distribution of heavy minerals within the area is uneven; highly radio-active rich sands contain 4-10% heavy minerals, while medium grades contain 2–4%. Table 2 gives the percentage composition of heavy minerals in the sands of Katahaldih area. The reserves of monazite per sq. mile of rich and medium grade sands, up to 3 ft. depth, have been estimated at 34,800 tons and 15,660 tons respectively (Shirke & Chatterji, *Proc. Second United Nations Intern. Conf. Peaceful Uses of Atomic Energy*, Geneva, 1958, **2**, 713; Bhola *et al.*, ibid., 100).

TABLE 2—HEAVY MINERALS PRESENT IN KATAHALDIH SANDS
(Figures give percentages by wt.)

	Rich sands	Medium grade sands
Monazite	1.00	0.45
Columbite-tantalite	0.20	0.11
Ilmenite	1.10	0.46
Zircon	0.40	0.04
Rutile	0.20	0.17
Sillimanite	1.00	0.80
Apatite	0.10	0.06
Magnetite	0.27	0.09
Total	4.27	2.18

Shirke & Chatterji, *Proc. Second United Nations Intern. Conf. Peaceful Uses of Atomic Energy*, Geneva, 1958, **2**, 715.

Monazite crystals, associated with pitchblende and columbite have been found in mica pegmatites at Abraki Pahar and near Pichhli in Gaya dist. The occurrences are only of mineralogical interest. In Hazaribagh dist., monazite occurs in the pink gneisses, *c.* 1 mile east of Bangaikalan (24°27′30″: 85°42′) [Dunn, *Mem. geol. Surv. India*, 1941, **78**, 233; Srivastava, *Rec. geol. Surv. India*, 1952, **88** (1), 135].

Gujarat—Monazite has been reported in the sand concentrates from Sabarmati river in the former Idar state (Roy, 1951, 142).

Kerala & Madras—The black coastal sands of Kerala and Madras States have been exploited for monazite and ilmenite for more than 50 years. The beach placers are derived chiefly from the granitic suite, particularly the pegmatites and gneisses forming the hinterland, and concentrated partly by river action, but largely by wave action of the sea which throws up the concentrates on the beach. The concentration is most noticeable in the bays and deltas. The deposits extend from Quilon to Cape Comorin on the west coast and thence up the east coast to Liparum in Tirunelveli dist. The more important deposits occur at Chavara near Quilon and at Manavalakurichi (8°8′:77°18′) in Kanyakumari dist. The former spreads over an area *c.* 14 miles long × 500–1,000 ft. wide; the Manavalakurichi deposit extends for about a mile from the mouth of Vallier river touching Kadiapatnam to Chinnavilai village. Systematic investigations of beach placers along the coastal belt have been recently taken up by the Department of Atomic Energy. The areas on the south-western coast contain on an average 0.75% monazite. The deposits have an average thickness of 25 ft. on the beach, and further inland 16 ft. The total reserves in the area investigated aggregate to 1.4 million tons of monazite. Individual occurrences with their reserves are given in Table 3. Monazite also occurs in the extensive *teri* deposit of Kanyakumari and Tirunelveli dist. The bed of the shallow sea off the Kerala coast also contains monazite (Mahadevan *et al.*, *Proc. Second United Nations Intern. Conf. Peaceful Uses of Atomic Energy*, Geneva, 1958, **2**, 103; *Annu. Rep. Dep. Atomic Energy*, 1959-60, 67).

Sand dunes with a fair proportion of monazite have been recorded at Anjengo, Cape Comorin and Muttam-Colachel areas and also at Sathankulam,

TABLE 3—MONAZITE OCCURRENCES OF KERALA AND MADRAS COASTS*

Locality	Area (in acres)	Monazite content (wt. %)	Monazite (thousand tons)
Cape Comorin - Vattakottai beach	36	1.565	23.1
do. do. interior	177	0.060	3.0
Muttam-Periyakattutura	287	0.277	45.0
Manavalakurichi	550	0.926	500.0
Manavalakurichi interior	172	1.316	76.8
Karumbana-Midalam beach	145	0.511	64.9
Karumbana-Midalam teri	200	0.795	54.0
Vilinjam-Kovalam beach	14	2.540	29.5
Kovalam-Pachallur beach	119	0.484	20.6
Veli-Kazhakuttam	44	0.627	10.0
Anjengo-Vettur	32	0.269	5.1
Odetti-Malapuram	8	7.055	36.8
Tiruvallavaram-Nindakara beach	35	0.938	20.0
Kannimelseri-Nindakara interior	165	0.583	45.3
Nindakara-Kayanakulam bay Trikunnapuzha	1,000	0.750	492.2

* Mahadevan *et al.*, *Proc. Second United Nations Intern. Conf. Peaceful Uses of Atomic Energy*, Geneva, 1958, **2**, 106.

Gulf of Manaar beach and Kudirmala Reserve Forest in Tirunelveli dist. [Tipper, *Rec. geol. Surv. India*, 1914, **44**(3), 189; Krishnan, *Mem. geol. Surv. India*, 1951, **80**, 284; *Annu. Rep. Dep. Atomic Energy*, 1958-59, 19].

Dark brown ferruginous grits composed of heavy minerals, including monazite, occur in some quantity near Varkala at the base of Varkalli cliff. Monazite also occurs in the dry beds of streams draining eastward from the hills in the Tirunelveli dist. In Kanyakumari dist., cheralite occurs in a kaolinised pegmatite at Kuttakushi and Cootykad Pothay [Tipper, *Rec. geol. Surv. India*, 1914, **44**(3), 190, 195; Coggin Brown & Dey, 278].

Madhya Pradesh—In Bundelkhand dist., deposits of monazite have been spotted in a few places; they are of little economic value. Monazite occurs in association with other heavy minerals in the sands of Gopad, Mohan and Dhamar rivers in Sidhi dist. and also in river sands in Shahdol dist.

Mysore—In Bangalore dist., coarse tabular crystals of monazite, associated with beryl, occur within 7-8 ft. depth in a highly decomposed pegmatite at Yedidur near Bangalore city. The deposit is not of any economic importance (*Quart. J. geol. Soc. India*, 1942, **14**, 180).

Orissa—Monazite-bearing sands occur at a number of places in Cuttack and Ganjam districts. The black sands found near the mouth of the Mahanadi river contain up to 2.5% monazite; low grade deposits, containing not more than 1% monazite, occur between Chilka lake and Chicocola river. In the former Jeypore state, now in Koraput dist., grains of monazite have been reported from the Kolab river bed. The mineral has also been reported in the sands of Wheeler Islands, between latitudes 20°44′ and 20°47′ and longitudes 87°3′ and 87°6′, and from near Dhenkenal [Narain, *Indian Miner.*, 1952, **6**, 71, 70; *Annu. Rep. Dep. Atomic Energy*, 1959-60, 59; Deekshitulu, *Rec. geol. Surv. India*, 1954, **85**(1), 63].

Rajasthan—In Udaipur dist., monazite occurs as crystalline aggregates in granitic rocks; it is found in Somiana mine in association with cassiterite, columbite-tantalite and beryl. Monazite occurs also in beryl workings at Lohagal in Ajmer-Merwara (Wadia, *J. sci. industr. Res.*, 1956, **15A**, 162; Narain, loc. cit.; Roy, *Mem. geol. Surv. India*, 1959, **86**, 63).

Mining and Treatment

The mining of monazite for the recovery of thoria and rare earth oxides is largely confined to the deposits at Chavara and Manavalakurichi. The beach sands are scraped from the surface with a spade; sands from dunes are collected by means of a wooden scraper, locally called *nagari*. The material is sun-dried and sent to beneficiation plants for concentration and subsequent separation of monazite from other heavy minerals.

The sands are collected in storage sheds whence they are sent to the processing plants. Four firms were formerly engaged in monazite winning, namely, the *Travancore Minerals Ltd.*, *Hopkins & William Ltd.*, *F.X. Pereira & Sons Ltd.* and the *Associated Minerals Co. Ltd.* The control of the deposits were taken over, in 1946, by the former Travancore State Government and the four firms were permitted to act as agents to the State Government. In 1956, the Government of India decided to nationalize the mineral sands industry by stages. The *Travancore Minerals Ltd.* was set up with a paid up capital of

Rs. 50 lakhs subscribed by the Government of India, Government of Travancore and the Government of Madras in the proportion of 50:45:5. The Company operates 3 winning plants at Chavara and 1 at Manavalakurichi. Only the surface sands are being exploited at present, but efforts are being made to mine the sands from depth with a view to increase the output. The material is first sieved through vibrating screens and then fed to magnetic separators to remove ilmenite. The monazite in the residual tailings is concentrated by gravity-cum-vibration using dry wind-tables. The process is repeated till a fraction containing *c.* 60% monazite is obtained. For further enrichment, the concentrate is passed through high intensity magnetic separators whereby the feebly magnetic monazite is separated from the non-magnetic constituents. The treatment is repeated and a product containing 97–99% monazite is obtained. The concentrates are despatched to *Indian Rare Earths Ltd.*, Alwaye, for recovering thorium, uranium and rare earths (*Indian Miner.*, 1959, **13**, 134).

The caustic soda digestion process is employed for recovering rare earths and thorium from monazite. The process consists of the following steps: (*i*) finely ground monazite (−300 mesh) is treated with hot concentrated aqueous caustic soda solution to convert the rare earths and thorium to hydroxides and the phosphate into trisodium phosphate; (*ii*) the insoluble hydroxides are separated from the solution by decantation; (*iii*) the mixed hydroxides are treated with a limited quantity of hydrochloric acid, just enough to dissolve the rare earth hydroxides, leaving the thorium hydroxide undissolved; the latter is separated from the soluble chlorides and sent to Trombay for further processing (Sethna & Fareeduddin, *Symposium on Rare Metals held in Bombay from December 1–3, 1957*, organized by UNESCO, Atomic Energy Establishment and Indian Institute of Metals, 68).

The crude thorium hydroxide cake from the Alwaye plant is further processed at the Thorium Plant set up by the Atomic Energy Commission at Trombay. Thorium cake is treated at the plant with an excess of hydrochloric acid and the thorium brought into solution. The solution, after filtration, is treated with an excess of sulphuric acid (50%) to precipitate the thorium as sulphate. Uranium and rare earths remain in solution and is despatched to the adjoining Uranium Metal Plant. Thorium sulphate is separated by centrifuging and purified by redissolving and reprecipitation. It is then converted to thorium nitrate *via* the hydroxide by treatment with nitric acid and packed for sale.

An alternate process for the recovery of rare earths and thorium from monazite is being investigated on a pilot plant scale. In this process, the crude thorium cake is dissolved in hydrochloric acid and treated with oxalic acid to precipitate thorium as oxalate. The oxalate is converted to hydroxide, dissolved in nitric acid and extracted with tributyl phosphate. Thorium is obtained by the electrolysis of potassium fluothorate in a batch containing potassium and sodium chloride or by the reduction of thoria with calcium chloride in an inert atmosphere (Sethna & Fareeduddin, loc. cit.).

Properties and Uses

Monazite consists principally of ortho-phosphates of cerium (Ce), lanthanum (La), neodymium (Nd) and praseodymium (Pr); an appreciable quantity of thorium is present. The mineral is associated with small quantities of silica, magnesia, alumina, rare earths of terbium and yttrium groups, uranium and occluded helium; mesothorium and radium are sometimes present in minute quantities. Analysis of a representative sample of monazite from Kerala-Madras coast gave the following values: Ceria, 30.6; lanthanum oxide, 15.7; neodymium oxide, 10.5; praseodymium oxide, 2.9; europium, gondolinium and terbium oxides, 0.7; yttrium oxide, 0.4; dysprosium, holmium, erbium, ytterbium and lutecium oxides, 0.1; thoria, 8.1; uranium oxide, 0.3; alumina, ferric oxide and lime, 1.0; and P_2O_5, 26.2%. The insufficiency of P_2O_5 to account for the entire quantity of thoria and rare earth oxides, and the invariable presence of silica have led to various theories regarding the composition of monazite sand (Wadia, *East. Met. Rev.*, 1958–59, **11**, 126; Mellor, V, 526).

Till recently thorium in the form of thorium nitrate was primarily used in the manufacture of incandescent gas mantles (composed of 99% thoria and 1% ceria) and, to a lesser extent, in the manufacture of refractories, alloys, polishing compounds and fine chemicals. Magnesium alloys containing thorium are important as materials of construction for supersonic planes, earth satellites and missiles. The importance of thorium, however, lies in its being a fuel for nuclear reactors of the breeder type.

Compounds of cerium, particularly the oxide and fluoride, are used in the cores of carbon arc

electrodes for increasing the luminosity. They are used as ingredients of polishing powders for lenses and mirrors, for colouring ceramics and in pharmacy. An alloy of iron with several rare earth elements is used as the sparking component in automatic lighters and other ignition devices. In the form of mischmetal, an alloy of cerium, lanthanum and neodymium, rare earths find several metallurgical applications. Magnesium-mischmetal is used for jet engine components and airframe structures; rare earth oxides and mischmetal are also valued as additives for special types of stainless steels. Metal surfaces are given a coating of rare earth oxides by flame spraying to improve corrosion-resistance (*Indian Rare Earths*, Atomic Energy Establishment, Trombay, 2; Sneed & Brasted, IV, 186).

Production and Trade

Prior to 1911, the world's supplies of monazite were almost entirely derived from Brazil. Production in India increased since 1910, and between that year and 1947 about 50,000 tons of monazite were exported. The export of the mineral has been banned since 1947 and production of monazite concentrate is controlled by the Department of Atomic Energy.

MONGOOSES (Class *Mammalia*, order *Carnivora*, sub-order *Aeluroidea*, family *Viverridae*, sub-family *Herpestinae*)

Fn. Br. Ind., Mammalia, II, 1941, 1-61.

Mongooses are small, terrestrial, weasel-like carnivores living in burrows and well known for their predatory habits. Typically, they have a broad head with pointed muzzle, short rounded ears, long body, short legs and long bushy tail and are covered with coarse, usually grizzled hair. They are active, alert and usually fearless and feed upon small mammals, birds and their eggs, snakes, rats, frogs and insects, and sometimes roots and fruits. They are distributed in S. W. Europe, Africa and southern Asia. Six species belonging to the genus *Herpestes* Illiger occur in India.

The Indian Grey Mongoose (*Herpestes edwardsi* Geoffroy) is distributed throughout India, inhabiting open lands and scrub jungles; it is sometimes seen in towns and villages occupying roofs and rafters of houses or sheltering in drains. The colour of the coat is typically iron-grey. The contour hairs on back are harsh and long with many alternate dark and light bands giving a speckled appearance to the coat. Three races of the mongoose are recognized: *H. e. nyula* Hodgson (Hindi—*Newala, nyul, rasu*; Beng.—*Naeul, beji*; Guj.—*Narulia*) is found at low altitudes from Nepal to Assam and from Kutch to Bengal, and is fairly common round about houses. *H. e. furrugineus* Blanford occurs in desert areas of N. W. India, particularly in Rajasthan; it is distinguished from *H. e. nyula* by its paler colour; the speckling on the coat is red or rich ochreus and completely red specimens are sometimes met with. *H. e. edwardsi* Geoffroy (Mar.—*Mungus*; Tel.—*Yentawa, mangisa*; Tam. & Mal.—*Kiri*; Kan.—*Mungasi, mungili*; Coorg—*Kera honkera*; Gond—*Koral*) is found in Peninsular India, south of Narbada river, from Ratnagiri to Travancore and Madura and in eastern ghats, up to an altitude of 1,370 m. It is distinguished from *H. e. nyula* by its darker tint, the blackish bands being more extensive than buff-white bands.

The Ruddy Mongoose (*Herpestes smithi* Gray) is represented in India by a single race. *H. s. smithi* Gray (Tel.—*Konda yentava*; Tam.—*Erimakiri-pilai*). It occurs from Rajasthan eastwards to Bengal and southwards to eastern and western ghats. It is closely related to the Indian grey mongoose, but is distinguished from it by its comparatively large size, black-tipped tail and darker colour with pronounced tendency to redness.

The Small Indian Mongoose [*Herpestes auropunctatus* Hodgson = *H. javanicus* (Geoffroy) of Pocock] lives and breeds in burrows and is especially valued as a snake-killer. It is of small size with tail shorter than the combined length of head and body; coat hair often silky when fresh; colour variable but always with fine speckling, contour hairs having as a rule only five rings. Two races of this mongoose are recognized: *H. a. auropunctatus* (Hodgson) (Kashmir—*Nul*), found in northern India from Kashmir to Bhutan, in Bengal, Manipur and Assam, and south of Ganges up to Chilka lake in Orissa and *H. a. pallipes* Blyth, found in the deserts of N. W. India.

The Indian Brown Mongoose (*Herpestes fuscus* Waterhouse) is represented in India by a single race. *H. f. fuscus* Waterhouse (Coorg—*Sendali-kera*). It is found in the hill forests of South India at altitudes of 900–1,800 m., and is fairly common near coffee plantations. It is of heavy build, blackish brown with fine buff or buff grey speckling.

The Stripe-necked Mongoose (*Herpestes vitticollis* Bennett) is the largest among the oriental

mongooses, and is easily distinguished by the presence of a black stripe running along the sides of the neck from behind the ear to the shoulder. It is typically a forest dweller, but is sometimes seen hunting for food in paddy fields. It ejects a secretion with a strong, musky odour from its anal glands to deter its enemies. Two races of the stripe-necked mongoose are known in India: *H. v. vitticollis* Bennett (TAM.—*Malam kiri*; COORG—*Quoki-balu, kati-kera*) occurs in western ghats and other hill tracts from Coorg to Travancore up to an altitude of 1,800 m. *H. v. inornatus* Pocock is found in North Kanara up to an altitude of 4,800 m.

The CRAB-EATING MONGOOSE (*Herpestes urva* Hodgson) is found in Assam, up to an altitude of 1,980 m. Though reported to live in holes and crevices, it is more aquatic in habit than the other species and lives mainly on crabs, fishes and snails. Like the striped-necked mongoose, it ejects a secretion from the anal glands to deter its enemies [Sterndale 109–14; Regan, 759–61; Pycraft, 872–73; Ellerman & Morrison-Scott, 279 98; Pocock, *J. Bombay nat. Hist. Soc.*, 1935–36, **38** (suppl.), 207; 1936–37, **39**, 211; Prater, 74–77].

Mongooses are especially serviceable for killing serpents; they destroy not only the eggs and young of the reptiles, but also kill venomous adult snakes. They are also useful for killing rats, scorpions, centipedes and other vermin. It is recorded that a consignment of the small Indian mongoose was shipped to Jamaica from Calcutta in 1872 for eradicating snakes and rats, which were severe pests of sugarcane crops there. The success achieved in controlling the pests in Jamaica led to its subsequent introduction in adjoining islands. Contrary to the general belief, the mongoose is not immune to snake venom; by its agility it avoids the fangs of the snake while fixing its own teeth in the back of the reptile's neck; further, when excited, the mongoose erects its long stiff hair and makes it difficult for the snake to drive its fangs through the hairs into the thick skin. If captured young, the mongoose can be tamed.

Though valued as a destroyer of vermin, the mongoose is sometimes responsible for wanton killing of poultry; even tamed animals are not free from this instinct (Prater, 69–73).

Moniera — *see* **Bacopa**

Monitors — *see* **Lizards**

Monkey Bread Tree — *see* **Adansonia**

Monkey Face Tree — *see* **Mallotus**

Monkey Jack — *see* **Artocarpus**

Monkey Nut — *see* **Arachis**

Monkey Puzzle — *see* **Araucaria**

MONKEYS AND APES (Class *Mammalia*, sub-class *Eutheria*, order *Primates*, sub-order *Anthropoidea*)

D.E.P., III, 460; V, 259; Fn. Br. Ind., Mammalia, I, 1939, 1-163.

*BROWN MONKEYS: HINDI & BENG.—*Bandar, wanar, kapi, markat*; MAR.—*Makad*; TEL.—*Kothi*; TAM.—*Kurangu*; KAN.—*Manga, kodaya*; MAL.—*Koranga*. BLACK MONKEYS: HINDI—*Kala bandar, siah bandar*; BENG.—*Neel bandar*; TEL.—*Kondamuchu*; TAM.—*Karunkurangu*; KAN.—*Kari manga, singalika*; MAL.—*Karingkorangu*.

The sub-order *Anthropoidea*, embracing monkeys, apes and man, is divided into two main series, *Platyrrhini* and *Catarrhini*. The platyrrhines, comprising the marmosets (*Callithricidae*) and the American monkeys (*Cebidae*), are characterized by flat noses with widely separated nostrils opening laterally, and are confined to the New World. The catarrhines have narrow noses with nares pointing downwards and include the Old World monkeys (*Cynomorpha*), apes and man (*Anthropomorpha*). The Old World monkeys (including langurs) are grouped under a single family, *Cercopithecidae*, with two sub-families, *Cercopithecinae* and *Semnopithecinae*; the former comprises 8 genera and some 137 species, while the latter includes 4 genera and about 78 species.

The cercopitheques are represented in India by the genus *Macaca* Lacepede (Macaques) and the semnopitheques by *Presbytis* Eschscholtz (Langurs) used in the broad sense so as to include the genera *Semnopithecus* Desmarest, *Trachypithecus* Reichenbach and *Kasi* Reichenbach. The macaques are distinguished from the langurs by the possession of well-developed cheek pouches into which they are able to store, temporarily, a great quantity of food which can be masticated at leisure; the stomach is simple. They are usually omnivorous and feed on insects and other animal matter as well as vegetable matter. The langurs, unlike the macaques, possess sacculated stomachs; they are vegetarian and feed mostly on leaves, tender shoots and fruits of trees. Indian monkeys are essentially arboreal and diurnal in habit. Seven species of macaques and 4 species of langurs with their races have been recorded in India.

*The vernacular names of monkeys in India in most cases pertain to the brown or black colour of the animal and are not specific.

Apes and man are included in the super-family *Hominoidea* and are distinguished from most other primates by the absence of a tail, the presence of vermiform appendix, a well organized or developed brain, and ability to assume an erect posture; except in man and adult gorilla, locomotion is mostly by brachiation or overarm swinging. The *Hominoidea* include two families: *Pongidae* (anthropoid apes) and *Hominidae* (man). Apes are represented in India by the common gibbon belonging to the sub-family *Hylobatinae* (Montagu, 43–73; Ellerman & Morrison-Scott, 192–212).

MONKEYS

Macaques—The BONNET MACAQUE [*Macaca radiata* (Geoffroy)] is a medium-sized, long-tailed monkey with a wig-like topknot of long dark hair radiating from a central point. It is represented by two races in India: *M. r. radiata* (Geoffroy) is found in the plains and hills of Peninsular India except Travancore, where it is replaced by the other race *M. r. diluta* Pocock.

The RHESUS MACAQUE [*Macaca mulatta* (Zimmermann)] has a pendulous tail and a greyish brown body, becoming orange red on the loin, rump and base of tail. Three races are distinguished in India: *M. m. mulatta* (Zimmermann) is the smallest of the three races. It is the common monkey of North India, found from Nepal, Bhutan and parts of Assam in the north as far south as the rivers Tapti and Godavari; it is common around tanks and temples and places of pilgrimage. *M. m. villosa* True (KASHMIR—*Wandar, puriz, ponj*) is found in the southern parts of Kashmir and in Punjab and Kumaon hills. The third race, *M. m. mcmahoni* Pocock is larger than the preceding two and is found in Kashmir.

FIG. 158. MACACA MULATTA—ADULT WITH YOUNG ONE

The ASSAMESE MACAQUE (*Macaca assamensis* M'Clelland) closely resembles the rhesus macaque in size, but the orange red colour on the hind quarters is absent. It is represented by two races: *M. a. assamensis* M'Clelland, occurring in Mishmi and Naga hills and possibly also in Sundarbans, and *M. a. pelops* Hodgson (LEPCHA—*Sahu*; BHOTIA—*Pio*; DARJEELING—*Panah bander*) found gregariously in the Himalayan forests from Mussoorie to Bhutan at altitudes of 610–1,830 m.; the latter bears a relatively longer tail.

The BLYTH'S PIG-TAILED MACAQUE is represented in India by a single race, *M. nemestrina blythi* Pocock (NAGA—*Kangh*), occurring in the forests of Naga hills. The STUMP-TAILED MACAQUE (*M. speciosa* F. Cuvier) (NAGA HILLS—*Chantee*) is also found in Naga hills and is distinguished from all other Indian macaques by the greatly reduced tail and by excessive elongation of the glans-penis. The LION-TAILED MACAQUE [*Macaca silenus* (Linn.)] is distributed chiefly in the western ghats from Kanara southwards. It is shining black in colour and is distinguished from all other macaques by the growth of long hair on temples and cheeks forming a mane; the tail is tufted at the extremity. The NICOBAR CRAB-EATING MACAQUE is represented in India by a single race, *Macaca irus umbrosa* Miller: it is a monkey frequenting tidal creeks and mangrove swamps in Nicobar Islands. It feeds chiefly on crustaceans along the shores and can swim and dive readily.

Langurs—The COMMON LANGUR or HANUMAN MONKEY [*Presbytis* (*Semnopithecus*) *entellus* Dufresne] is distributed in almost all parts of India except the western desert. It is pale grey in colour, the hands, feet and face being black with overhanging eyebrows of stiff hair. The differences in the intensity of colour of this langur from various localities are associated with the environment. Fourteen races are distinguished: *P. e. schistaceus* Hodgson (KUMAON—*Gooni*) occurs in Nepal terai, Oudh, Kumaon and

Photo : M. Krishnan

FIG. 159. PRESBYTIS (SEMNOPITHECUS) ENTELLUS—MALE AND FEMALE ADULTS

Garhwal up to an altitude of 2,750 m. ; it descends to lower altitudes in winter ; *P. e. achilles* (Pocock) (Lepcha—*Sahu kaboo ;* Bhotia—*Propyaka*), and *P. e. ajax* (Pocock) are found at high altitudes, the former in Sikkim and Nepal and possibly in Kashmir and the latter, in the higher regions of the mountains of Chamba, Kangra and Kulu, and possibly in Kashmir : *P. e. entellus* (Dufresne) occurs south of the river Ganges from Bengal to Gujarat and is common both in forests and around villages and towns ; *P. e. anchises* (Blyth) is found in Madhya Pradesh and eastern ghats ; it is distinguished from the other races by its paler and mottled hands and feet ; *P. e. achates* (Pocock) occurs in Dharwar, Bellary and Kanara ; it differs from *P. e. entellus* principally by its darker dorsal colour and paler crown ; *P. e. iulus* (Pocock) has been recorded from Jog near Gersoppa falls (Mysore) : *P. e. aeneas* (Pocock) is a dark coloured langur found in south Coorg : *P. e. dussumieri* Geoffroy, *P. e. hypoleucos* Blyth, *P. e. priamellus* (Pocock) and *P. e. thersites* (Blyth) (Tam.—*Mundi*) occur in Kerala ; *P. e. priam* Blyth is found in Dharmapuri, Shevaroy, Palkonda and Nilgiri hills in South India ; and *P. e. elissa* (Pocock) has been recorded from Nagarhole (Coorg) and is distinguished by its black hands and feet which contrast sharply in colour from that of the body.

The Capped Langur [*Presbytis* (*Trachypithecus*) *pileatus* (Blyth)] is a large-sized animal with a black face and a crown of erect long hair directed backwards from the forehead. Four races of the langur, all from Assam, have been reported: *P. p. pileatus* (Blyth), *P. p. durga* (Wroughton), *P. p. tenebricus* (Hinton) and *P. p. brahma* (Wroughton).

The Nilgiri or John's Langur [*Presbytis* (*Kasi*) *johni* (Fischer)] is found in the hill tracts of western ghats from Coorg southwards, Nilgiri, Anaimalai, Brahmagiri, Tirunelveli and Palni hills, usually not below 900 m. The species was once very common on Nelliampathy hills, but its number has been reduced owing to persecution by tribal people for its flesh.

The Golden or Sankosh Langur (*Presbytis geei* Khajuria) is distributed in the Goalpara district (Assam) and probably extends to north Kamrup. It is distinguished from other langurs by the presence, on the throat, of a prominent orange red patch which extends to the cheeks, sides of neck and chest.

Macaques and langurs move about in groups and cause considerable depredation of agricultural and horticultural crops. In towns and villages, they are

notorious for robbing eatables and damaging household effects; their control is difficult on account of the religious abhorrence of killing monkeys.

Some macaques and langurs are hunted for their flesh, furs and skins. The flesh of *M. assamensis pelops, M. speciosa, P. entellus, P. e. hypoleucos* and *P. johni* is eaten by some tribal people; the flesh and blood of *M. assamensis pelops* and *P. johni* are considered medicinal. The skin of *P. johni* is used for drums (Regan, 860–73; Sterndale, 7–21; Prater, 12–19; Pycraft, 780–98, 900–7, 911–14; Ellerman & Morrison-Scott, 192–211; Muir, *J. Bombay nat. Hist. Soc.*, 1915–16, **24,** 353; Hinton & Wroughton, ibid., 1920–21, **27,** 665, 813; Hinton, ibid., 1923–24, **29,** 77; Leigh, ibid., 1924–25, **30,** 691; Pocock, ibid., 1927–28, **32,** 472, 503, 660; McCann, ibid., 1928–29, **33,** 192; 1931–32, **35,** 51, 276, 297, 530; Angela Nolte, ibid., 1955–56, **53,** 177; Gee, ibid., 1955–56, **53,** 252; Ishwar Prakash, ibid., 1958, **55,** 154; Mathur, *Indian For.*, 1954, **80,** 427; Tiwari, ibid., 1955, **81,** 154; Parija, *Indian Fmg*, 1947, **8,** 520).

Thousands of rhesus monkeys are caught alive and exported every year from India, chiefly to U.S.A., Canada, W. Germany, U.K. and U.S.S.R. for use as experimental animals in pathological, aeronautical and astronautical investigations. Salk vaccine, used against poliomyelitis is prepared from tissue cultures of monkey kidney. Available information on the export of monkeys from India is summarized in Table 1.

Apes

The family of apes (*Pongidae*) include the chimpanzee, gorilla, orang-utan and gibbon; of these only the last is found in India. It is the smallest among apes, slightly under 3 ft. in height, with very long arms. It is capable of walking on the ground in a bipedal posture, using the arms for balancing. The long upper extremities facilitate overarm swinging and the brachiating mode of progression through trees.

TABLE 1—EXPORT OF MONKEYS FROM INDIA

	Number	Value Rs.
1953–54	16,281	2,97,303
1954–55	1,00,330	18,15,221
1955–56	1,16,296	28,57,557
1956 (April–Dec.)	1,49,097	68,79,286
1957	1,90,844	1,27,65,615
1958	1,01,053	62,10,950
1959	1,55,614	89,35,747
1960–61	1,21,747	63,07,873

The Hoolock or Common Gibbon [*Hylobates hoolock* (Harlan)] (Hindi—*Uluk*) is found in India only in the forests of Assam. Hoolocks may occasionally leave the forest and enter villages to plunder gardens (Montagu, 69; Prater, 11; Sterndale, 4–6; Regan, 873–76; Pycraft, 917–18; Ellerman & Morrison-Scott, 212; McCann, *J. Bombay nat. Hist. Soc.*, 1932–33, **36,** 395; Peart, ibid., 1934–35, **37,** 214).

Monkshood — *see* **Aconitum**

MONOCHORIA Presl (*Pontederiaceae*)

A small genus of rhizomatous aquatic herbs distributed from North-East Africa to Manchuria and southward to South Australia. Two species occur in India.

M. hastata Solms syn. *M. hastaefolia* Presl

Fl. Br. Ind., VI, 362; Fl. Malesiana, Ser. I, **4**(3), 257, 258, Fig. 1.

Tel. *Nir-tamara;* Mal.—*Karinkuvalam, kolachempu.*

Mundari—*Huring demdem, dumdum ara.*

A perennial herb with elongate, creeping, spongy rootstock found in the margins of tanks and ponds, swamps, ditches, marshes, rice fields and sometimes in brackish water, almost throughout India. Leaves long-petioled, sagittate, hastate or cordate; flowers purplish-blue or violet blue dotted with red, in subumbellate racemes; capsules small, ellipsoid, subglobose or oblong.

Tender stalks and leaves of the plant are eaten as vegetable; rootstocks are used as food for cattle and pigs. The plant is considered alterative, tonic and cooling. A juice of the leaves is applied to boils. In Celebes, rhizomes, pounded with charcoal, are used for scurf (Macmillan, 302; Burkill, II, 1489; Uphof, 241; Chopra, 508).

M. vaginalis Presl

Fl. Br. Ind., VI, 363; Fl. Malesiana, Ser. I, **4**(3), 256; Kirt. & Basu, Pl. 979.

Beng.—*Nukha, nanka;* Tel.—*Nirkancha;* Mal.—*Kakapola.*

An aquatic herb with short, sub-erect spongy rootstocks found in rice fields, ditches, margins of tanks and pools, swamps and marshes almost throughout India, ascending up to 1,500 m. in the hills. Leaves

FIG. 160. MONOCHORIA HASTATA—FLOWERING BRANCH

long-petioled, linear to ovate and ovate-cordate or sub-reniform ; flowers blue, usually spotted with red, in sub-spicate racemes ; capsules ellipsoid.

The entire plant, excepting the roots, is eaten as vegetable. In Java, juice of leaves is taken for coughs and that of roots for stomach and liver complaints, asthma and toothache (Kirt. & Basu, IV, 2530).

MONOTROPA Linn. (*Monotropaceae ; Pyrolaceae*)

Fl. Br. Ind., III, 476 ; Collett, 295, Fig. 90.

A small genus of saprophytic herbs, devoid of chlorophyll, distributed in North and South America and Asia. One species occurs in India.

M. uniflora Linn. (INDIAN PIPE), a glabrous, whitish herb, 15.0–37.5 cm. high, with broadly lanceolate scales and scape, terminated by solitary, white flower, is found in the temperate Himalayas and Khasi hills, at altitudes of 1,800–2,400 m. The plant contains a toxic bitter principle ($C_{31}H_{50}O_{10}$). Aqueous and acetone extracts of the stem are active against Gram-positive bacteria. The root is considered sedative, nervine tonic and antispasmodic (Wehmer, II, 906 ; Nickell, *Econ. Bot.*, 1959, **13**, 281 ; Hocking, 143).

MONSTERA Adans. (*Araceae*)

A small genus of tropical evergreen climbers native of West Indies and tropical America. One species has been introduced in India and grown in gardens for its ornamental foliage and edible fruits.

M. deliciosa Liebm. syn. *Philodendron pertusum* Kunth & Bouche CERIMAN

Bailey, 1947, II, 2063, Fig. 2385.

A large climber, native of central America, cultivated in gardens throughout India for its large, bright green, perforated leaves and cone-like fruits up to 25.0 cm. long. The plant can be propagated by seeds but usually stem cuttings are employed. It grows well on any well-drained soil and needs a

Bot. Surv. India

FIG. 161. MONSTERA DELICIOSA—FRUITING BRANCH

support to climb up. When grown for fruits it should be pruned and not allowed to grow more than 2.4–3.0 m. The vines produce fruits in about 2–3 years after planting [Gopalaswamiengar, 361; *Bull. nat. bot. Gdns, Lucknow*, No. 7, 1958; Singh & Johal, *Indian Hort.*, 1958–59, **3**(2), 19; Naik, 407; Krishnamurthi, 114].

The fruits are edible and take about a year to mature after flowering. The ripening is gradual from base upwards and the fruits are ready for use in about a week or more after picking, when all the scales fall off. The fruits have a mixed flavour of pineapple and banana and are considered a delicacy. Unless washed well before eating, the remnants of the flowers are said to create irritation of the throat. Consumption of the fruit also causes sometimes allergy or anaphylaxis (Naik, 407; Singh & Johal, loc. cit.; Burkill, II, 1490; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 20).

The aerial roots of this plant are reported to be used in Mexico for making strong baskets [Standley & Steyermark, *Fieldiana, Bot.*, 1958, **24**(1), 331].

Moon Flower — *see* **Calonyction**

Moon Plant — *see* **Sarcostemma**

Morchella — *see* **Fungi**

Morel — *see* **Fungi**

MORINA Linn. (*Dipsacaceae*)

A small genus of perennial herbs native of Asia. Six species occur in India.

M. longifolia Wall.

Fl. Br. Ind., III, 216; Coventry, I, Pl. XXII.

A tall spinous herb, 60–120 cm. high, found in temperate and alpine Himalayas, from Kashmir to Bhutan, at altitudes of 2,400–4,200 m. Leaves opposite or in whorls of three, long, narrow, prickly with spiny teeth; flowers variegated rose pink and white, in distant whorls in leaf axils forming a long interrupted spike.

The plant possesses strong aromatic properties; it is used as an incense and in the preparation of *dhup*, *agarbatties*, etc. On steam-distillation, the plant yields 0.34% of an essential oil (sp. gr.$^{15°}$, 0.9525; $n^{20°}$, 1.4775) [Handa *et al.*, *J. sci. industr. Res.*, 1957, **16A** (5), suppl., 18].

M. coulteriana Royle is a tall herb, 30–90 cm. high, with showy flowers found in sub-alpine western Himalayas, from Kashmir to Garhwal, at altitudes of 2,700–3,900 m. The plant is used as incense. This species and also *M. persica* Linn., a tall herb, 45–120 cm. high, are ornamental and suitable for growing in borders; the latter is considered medicinal (Chittenden, III, 1320).

MORINDA Linn. (*Rubiaceae*)

A genus of shrubs and small trees distributed throughout the tropics. About 8 species are found in India.

The roots of many of the species of *Morinda* were at one time used in various parts of India for dyeing cotton and also wool and silk, under the names *al*, *ach*, *surangi*, etc. *M. citrifolia* and *M. coreia* are considered to be the chief sources of *al* dye; some of the other species of the genus, particularly *M. bracteata*, *M. tomentosa* and *M. umbellata*, were also exploited for the same purpose. Some authorities in the past, considered most of these dye yielding species as mere forms of the very variable *M. citrifolia* (Burkill, II, 1491–95; Thorpe, VIII, 236–38; *Agric. Ledger*, 1895, 129).

M. angustifolia Roxb.

D.E.P., V, 260; C.P., 782; Fl. Br. Ind., III, 156.

BENG.—*Asho*, *darhharidra*.

NEPAL—*Barr-hardi*; LEPCHA—*Huldi-kung*; ASSAM—*Asu-goch*; KHASI—*Dieng-nong*, *dieng-seroi*; GARO—*Chhennong*; LUSHAI—*Kawnpel*.

A shrub or a small tree found in eastern Himalayas, Assam, Bihar, Orissa and Andhra Pradesh up to an altitude of 1,800 m. Leaves large, elliptic or obovate lanceolate; flowers white, fragrant.

The roots yield a yellow dye which was formerly used for dyeing cotton yarn and cloth; red shades are obtained on mordanted yarn by using cold water extracts of the root.

M. citrifolia Linn.

D.E.P., V, 261; C.P., 783; Fl. Br. Ind., III, 155.

HINDI, BENG., GUJ. & MAR.—*Al*, *ach*, *surangi*, *bartundi*; TEL.—*Maddi*, *togaru*; TAM.—*Nuna*, *togaru*; KAN.—*Ainshi*, *tagase*, *maddi*; MAL.—*Kattapitalavam*, *mannanatti*; ORIYA—*Achu*, *pindra*.

A small tree with a straight trunk, formerly cultivated throughout the greater part of India and now found only in the wild state or as an escape in parts of Bengal, Bihar, Orissa, west coast and Andaman Islands. Leaves broadly elliptic, bright green, glabrous; flowers white, in dense ovoid heads; fruits ovoid, glossy, white when ripe; pyrenes compressed, winged on edges.

M. citrifolia was formerly cultivated as a field crop on an extensive scale and its roots exploited as the source of *al* dye. Under the conditions of cultivation, the plant begins to bear flowers and fruits within 2–3 years of planting. The roots are dug out when the plants are 3–4 years old, dried and sorted for use by the dyeing trade; roots thicker than 1.3 cm. are discarded as worthless. The colouring matter resides in the root bark and is present to the maximum extent when the plants are 3–4 years old. Mature trees hardly contain a trace of it. For dyeing, the roots are chipped and given a preliminary steeping in water to wash off the free acids. Best results in dyeing are obtained from a neutral dye-bath of washed morinda root. Red, purple and chocolate shades are produced on mordanted cotton, silk or wool, the shades being fast to soap. The dyeing power of morinda root, when necessary precautions are taken, excels that of madder. The use of *al* dye has been virtually abandoned since the advent of synthetic dyestuffs (Thorpe, VIII, 236–38).

The colouring principle of morinda root is morindone (trihydroxy methylanthraquinone, $C_{15}H_{10}O_5$, m.p. 281–82°), present in the bark mainly as the glucoside morindin ($C_{27}H_{30}O_{14}$, m.p. 264.5° decomp.); on hydrolysis morindin yields glucose, rhamnose and morindone. The root contains, in addition, rubichloric acid, alizarin α-methyl ether, rubiadin-1-methyl ether, two isomeric dihydroxy methylanthraquinones (morindadiol, $C_{15}H_{10}O_4$, m.p. 244°; and soranjidiol, m.p. 276°), and two trihydroxy methylanthraquinone mono methyl ethers (m.p. 216° and 172°). Morindone may be conveniently prepared in quantity by extracting the roots with sulphurous acid; the non-tinctorial yellow compounds are obtained as by-products; morindone has been synthesized. The woody part of the root hardly contains any morindone; it contains mostly yellow colouring principles (Thorpe, VIII, 236–38; Mayer & Cook, 127–29; Heilbron & Bunbury, III, 535; Perkin & Everest, 47; Bhattacharya & Simonsen, *J. Indian Inst. Sci.*, 1927, **10A**, 6).

M. citrifolia is grown as a shade tree and as support for pepper vines. Tender leaves are reported to be eaten as pot-herb in times of scarcity; fruits are also eaten. The tree is lopped for fodder and leaves are used to rear silkworms. The pulp of the fruit is used for cleansing hair. The fruits yield a small amount of yellow essential oil (sp. gr.$^{13°}$, 0.927) consisting mainly of hexoic and octoic acids with small quantities of a paraffin (m.p. 60°) and esters of ethyl and methyl alcohols. The wood of the tree is yellowish brown, fairly hard and close-grained; it is used for turning and for making plates and toys (Burkill, II, 1493–94; Laurie, *Indian For. Leafl.*, No. 82, 1945, 15; Kirt. & Basu, II, 1295; Finnemore, 818; Rama Rao, 214).

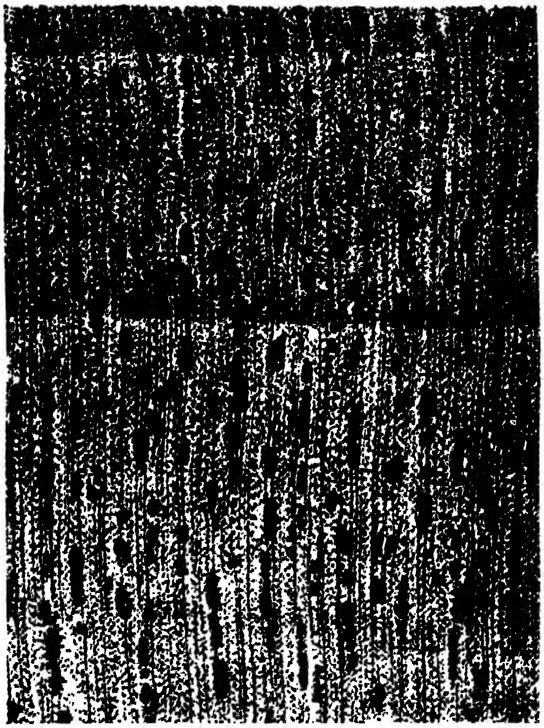
Most parts of the plant are reported to possess medicinal properties. The root is used as a cathartic and febrifuge, and applied externally to relieve pain in gout. Leaves are considered tonic and febrigue; they are used as a healing application for wounds and ulcers; the juice of the leaves is externally applied in gout. Fruits are used for spongy gums, throat complaints, dysentery, leucorrhoea and sapraemia (Chopra, 1958, 514; Kirt. & Basu, II, 1295; Burkill, II, 1493–94).

***M. coreia** Buch.-Ham. syn. *M. tinctoria* Roxb.
D.E.P., V, 274; C.P., 783; Fl. Br. Ind., III, 156.

A small to medium-sized tree with a straight

FIG. 162. MORINDA COREIA—FLOWERING AND FRUITING BRANCH

* *M. coreia* has been considered by some authors as the wild form or a variant of *M. citrifolia*. It is generally known by the same vernacular names as those of *M. citrifolia* and is put to similar uses.



F.R.I., Dehra Dun. Photo: S. S. Ghosh

FIG. 163. MORINDA COREIA—TRANSVERSE SECTION OF WOOD (×10)

cylindrical stem, 3.6–4.2 m. in length and c. 90 cm. in girth, found in dry forests throughout the greater part of India; it is cultivated in some places. Bark corky, pale brown, long fissured; leaves elliptic or lanceolate; flowers in dense ovoid heads, white, scented; fruit a drupe, globose or ovoid, c. 2 cm. in diameter, edible.

The tree is lopped for fodder. Analysis of leaves gave the following values: nitrogen, 2.02; calcium (as CaO), 3.77; and ash, 9.33%. The roots of the plant, like those of *M. citrifolia* were formerly used in dyeing cotton (Laurie, loc. cit.; Puri, *J. Indian bot. Soc.*, 1954, **33**, 17).

The wood is light red when freshly cut, often with yellow streaks, changing to dull red with age. It is smooth, somewhat lustrous, straight-grained, medium-textured, moderately hard to hard and light (sp. gr., 0.52; wt., 34 lb./cu. ft.). The wood is liable to warping and end-splits during seasoning; green conversion of logs and stacking under cover with ends protected are recommended. It is durable, saws easily and can be worked to a good surface. The wood is used for making plates and dishes, occasionally for yokes and combs; it may be used for furniture, toys, cotton reels, slate frames and pen holders (Pearson & Brown, II, 656–58).

The root bark of *M. coreia* contains morindone and its glucoside morindin. The heartwood contains three anthraquinone pigments, namely, morindone, damnacanthal ($C_{16}H_{10}O_5$, m.p. 212°) and *nor*-damnacanthal ($C_{15}H_8O_5$, m.p. 218–20°) (Thorpe, VIII, 236; Murti *et al.*, *J. sci. industr. Res.*, 1959, **18B**, 367).

M. umbellata Linn.; Hook. f. (Fl. Br. Ind.) in part

D.E.P., V, 275; C.P., 784; Fl. Br. Ind., III, 157.

A diffuse or climbing shrub found in Khasi hills, Bihar and Deccan Peninsula at an altitude of 1,500 m. Leaves elliptic, oblong or lanceolate; flowerheads in terminal sessile umbels; fruit scarlet, lobed.

The fruits of the plant are edible; green fruits are used in curries. A decoction of roots and leaves is considered useful in diarrhoea and dysentery (Kirt. & Basu, II, 1296).

The root bark contains the colouring principles, morindone and morindin. It contains, in addition, a considerable amount of rubichloric acid and small quantities of a trihydroxymethyl anthraquinone methyl ether (m.p. 216°), morindanigrin, $C_{16}H_{10}O_5$ (m.p. 210°), 1,3-dihydroxy-6-methyl anthraquinone (m.p. 269°), a derivative of dimethyl anthraquinone, $C_{16}H_{12}O_6$ (m.p. 258°) and a hydroxy-methyl anthraquinone carboxylic acid, $C_{16}H_{10}O_5$ (m.p. 198–99°) (Thorpe, VIII, 238; Mayer & Cook, 129).

M. bracteata Roxb. syn. *M. citrifolia* var. *bracteata* Hook. f. (Fl. Br. Ind.) is a shrub or a small tree found in the coastal forests of Bengal and Deccan Peninsula. The roots of the plant were formerly used in dyeing (Benthall, 277–78).

M. tomentosa Heyne ex Roth syn. *M. tinctoria* var. *tomentosa* Hook. f. (Fl. Br. Ind.) is a small tree found throughout the greater part of North India and Deccan Peninsula. The root bark yields the *al* dye. The fruit is eaten. The wood is used for making plates and dishes (Talbot, II, 123).

MORINGA Adans. (*Moringaceae*)

A small genus of quick-growing trees distributed in India, Arabia, Asia Minor and Africa. Two species are recorded from India, of which one, *M. oleifera*, is widely cultivated in the tropics for its edible fruits.

M. oleifera Lam. syn. *M. pterygosperma* Gaertn. DRUMSTICK TREE, HORSE RADISH TREE

D.E.P., V, 276; C.P., 784; Fl. Br. Ind., II, 45.

SANS.—*Shobhanjana*; HINDI—*Mungna, sainjna, shajna*; BENG.—*Sajina*; MAR.—*Achajhada, shevgi*; GUJ.—*Midhosaragavo, saragavo*; TEL.—*Mulaga, munaga, tellamunaga*; TAM.—*Murungai*; KAN.—*Nugge*; MAL.—*Murinna, sigru, moringa*.

ASSAM—*Saijna, sohjna*; ORISSA—*Sajina*; PUNJAB—*Sainjna, soanjna*; SANTAL—*Munga arak*.

A small or medium-sized tree, about 10 m. high, found wild in the sub-Himalayan tract, from Chenab eastwards to Sarda, and cultivated all over the plains of India. Bark thick, soft, corky, deeply fissured; young parts tomentose; leaves usually tri-pinnate; leaflets elliptic; flowers white, fragrant, in large panicles; pods pendulous, greenish, 22.5–50.0 cm. or more in length, triangular, ribbed; seeds trigonous with wings on angles.

The tree is indigenous to North-West India and is plentiful on recent alluvial land in or near sandy beds of rivers and streams. It is often cultivated in hedges and homeyards. It grows in all types of soils, except stiff clays and thrives best under the tropical insular climate of S. India. The tree can be propagated by seeds or from cuttings; cuttings are preferred. Plants raised from seeds produce fruits of inferior quality. Further, cuttings of fairly large size, planted in moist soil, strike root readily and grow to sizeable trees within a few months. Under N. Indian conditions, the tree sheds its leaves in December–January and new leaves appear in February–March. They are followed by flowers and long whip-like tender fruits, which ripen during summer. Sometimes, particularly in S. India, flowers and fruits appear twice a year. A good tree yields as many as 1,000 fruits (Troup, I, 250; Benthall, 138; Muthuswamy, *S. Indian Hort.*, 1954, **2**, 18; *Bull. Indian Cocon. Comm.*, 1954–55, **8**, 101).

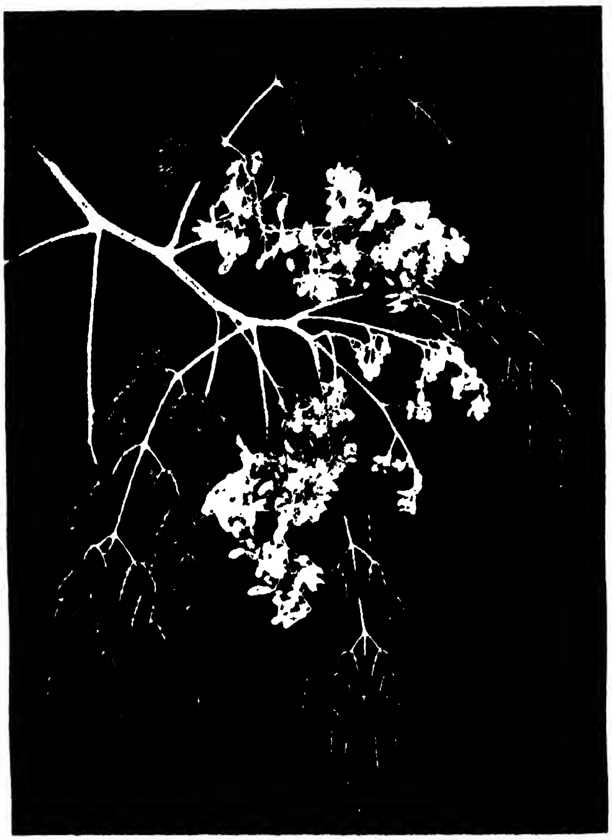


FIG. 164. MORINGA OLEIFERA—FLOWERING BRANCH

There are not many named varieties of this tree in India. A type, named *Jaffna*, grown in parts of S. India produces fruits 60–90 cm. in length; *Chavakacheri murunga*, also a *Jaffna* type, bears fruits as long as 90–120 cm.; *Chem murunga* is a type yielding pods with red tips. Trees growing wild usually bear inferior, sometimes bitter, fruits (Muthuswamy, loc. cit.).

The tree is not affected by any serious disease in India. A foot-rot, caused by *Diplodia* sp., has been observed in Madras. Two caterpillars and a stem borer are known to affect the tree. Of these, the hairy caterpillar, *Eupterote mollifera* Wlk., causes defoliation; it is controlled by spraying the tree with fish oil-rosin soap or BHC, or by burning with lighted torch (*Mem. Dep. Agric. Madras*, No. 36, 1954, 1067; Ramakrishna Ayyar, 266; Muthuswamy, loc. cit.)

The tree is valued mainly for the tender pods which are esteemed as vegetable. They are cut into slices and used in culinary preparations; they are also pickled. Flowers and tender leaves are eaten as pot herb. Seeds are consumed after frying; they are reported to taste like peanuts. The roots of the tree are used as condiment or garnish in the same way as those of true horse radish (*Cochlearia armoracia*). Twigs and leaves are lopped for fodder (Burkill, II, 1496; Parker, 121; *Jl Publ. imp. agric. Bur.*, No. 10, 1947, 111).

All parts of the tree are considered medicinal and used in the treatment of ascites, rheumatism, venomous bites and as cardiac and circulatory stimulants. The root of the young tree and also root bark are rubefacient and vesicant. The leaves are rich in

vitamins A and C and are considered useful in scurvy and catarrhal affections; they are also used as emetic. A paste of the leaves is used as an external application for wounds. Flowers are used as tonic, diuretic and cholagogue. The seeds are considered antipyretic, acrid and bitter. The seed oil is applied in rheumatism and gout (Burkill, II, 1496; Dalziel, 23; Chopra *et al.*, 161–63; Chopra, 1958, 365–67; Kirt. & Basu, I, 678–80).

Analysis of pods gave the following values: moisture, 86.9; protein, 2.5; fat (ether extr.), 0.1; carbohydrates, 3.7; fibre, 4.8; and mineral matter, 2.0%: calcium, 30; phosphorus, 110; and iron, 5.3 mg./100 g.; copper (3.1 μg./g.), iodine (18 μg./kg.) and oxalic acid (0.01%) are present. The pods contain: carotene (as vitamin A), 184 i.u.; nicotinic acid, 0.2 mg.; and ascorbic acid, 120 mg./100 g. Pressed juice of the pods contains ascorbic acid oxidase (*Hlth Bull.*, No. 23, 1951, 38; Bagchi & Chowdhury, *Ann. Biochem.*, 1949, **9,** 107; Iodine Content of

FIG. 165. MORINGA OLEIFERA—FRUITING BRANCH

Foods, 126; Basu & Ghosh, *Indian J. med. Res.*, 1943, **31,** 29; Srinivasan, *Curr. Sci.*, 1935–36, **4,** 407).

The pods contain a globulin (N, 15.6; sulphur, 1.58%) and a prolamin (N, 14.02; sulphur, 1.43%). The essential amino acids present in the total proteins are (g./16 g. N): arginine, 3.6; histidine, 1.1; lysine, 1.5; tryptophan, 0.8; phenylalanine, 4.3; methionine, 1.4; threonine, 3.9; leucine, 6.5; isoleucine, 4.4; and valine, 5.4. Non-protein nitrogen forms 56.9% of the total nitrogen. The distribution of amino acids in the non-protein fraction is as follows: histidine, 4.6; arginine, 48.0; threonine, 19.5; valine, 27.5; methionine, 2.6; phenylalanine, 5.6; isoleucine, 15.0; leucine, 18.2; and tyrosine, 3.7 mg./100 g.; lysine and tryptophan, traces; and cystine, nil. The pods are remarkably rich in free leucine (Rau & Ranganathan, *J. Indian Inst. Sci.*, 1937, **20A,** 49; Kuppuswamy *et al.*, 116; Kulkarni & Sohonie, *Indian J. med. Res.*, 1956, **44,** 511).

The leaves are rich in carotene and ascorbic acid. Analysis gave the following values: moisture, 75.0; protein, 6.7; fat (ether extr.), 1.7; carbohydrates, 13.4; fibre, 0.9; and mineral matter, 2.3%: calcium, 440; phosphorus, 70; and iron, 7.0 mg./100 g.; copper (1.1 μg./g.) and iodine (51 μg./kg.) are present. Leaves contain: carotene (as vitamin A), 11,300 i.u.; vitamin B_1, 210 μg.; nicotinic acid, 0.8 mg.; ascorbic acid, 220 mg.; and tocopherol, 7.4 mg./100 g. Estrogenic substances and a pectinesterase are reported to be present. Attempts have been made to prepare ascorbic acid concentrates by extracting leaves with water, concentration and dehydration. For this purpose, leaves are collected during the period of maximum vegetable growth; the vitamin is fairly stable in aqueous extracts, the loss observed even after 3 days of storage being 25%. Ascorbic acid oxidase is elaborated in the leaves after the tree flowers and the vitamin is rapidly destroyed in aqueous extracts of leaves gathered after the flowering stage (*Hlth Bull.*, No. 23, 1951, 32; *Chem. Abstr.*, 1947, **41,** 5643; Iodine Content of Foods, 126; Bagchi & Chowdhury, loc. cit.; Pithawala & Sreenivasan, *Proc. nat. Inst. Sci. India*, 1951, **17,** 265; *J. Indian Inst. Sci.*, 1958, **40A,** 83; Panse & Sreenivasan, *Curr. Sci.*, 1945, **14,** 303).

The essential amino acids present in the leaf proteins are (g./16 g. N): arginine, 6.0; histidine, 2.1; lysine, 4.3; tryptophan, 1.9; phenylalanine, 6.4; methionine, 2.0; threonine, 4.9; leucine, 9.3; isoleucine, 6.3; and valine, 7.1. The biological value and digestibility co-efficient of leaf proteins (at 5%

level of protein intake) are respectively 41% and 77%. Non-protein nitrogen accounts for 16% of the total nitrogen of tender leaves. The nitrogen distribution in the non-protein fraction is as follows: sol. humin N, 5.25; insol. humin N, 5.25; amide N, 7.89; basic N, 34.21; and non-basic N, 47.37%. Feeding trials with rats have shown that drumstick leaf powder has a high supplementary value to rice diet (Kuppuswamy *et al.*, 112, 116; Swaminathan, *Indian J. med. Res.*, 1937-38, **25,** 847; Rau & Ranganathan, *Curr. Sci.*, 1937-38, **6,** 609; Sur, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1954-55, **4,** 159).

The flowers contain traces of alkaloids; they also contain a wax (m.p. 69-72°; acid val., 10.5; sap. val., 29.8; and unsapon. matter, 75.5%), quercetin and kaempferol; the ash is rich in potassium and calcium (Rangaswami & Sankarasubramanian, *Curr. Sci.*, 1946, **15,** 316; Pankajamani & Seshadri, *Proc. Indian Acad. Sci.*, 1952, **36A,** 157).

Seed oil—The seeds (av. wt. of seed, 0.3 g.; shell, 26-30%; kernel, 70-74%) are oleaginous. Analysis of the kernel gave the following values: moisture, 4.0; crude protein, 38.4; fatty oil, 34.7; N-free extr., 16.4; fibre, 3.5; and mineral matter, 3.2%. A pale yellow non-drying oil with a mild pleasant flavour can be extracted from the kernel; it deposits stearin on chilling. The characteristics of the oil are as follows: sp. gr.^{30}, 0.8984; n^{30}, 1.4652; acid val., 3.5; sap. val., 182.2; iod. val., 64.2; R.M. val., 0.44; acet. val., 11.5; Hehner val., 91.6; and unsapon. matter, 3.05%. The component fatty acids of the oil are: palmitic, 9.3; stearic, 7.4; behenic, 8.6; and oleic, 65.7%; the presence of myristic and lignoceric acids has been reported by some authors; *glyceride composition:* trisaturated, 1.40; disaturated mono-unsaturated, 23.47; monosaturated di-unsaturated, 25.62; and tri-unsaturated, 49.51%. The proportion of acids found in oil samples from Haiti and Trinidad are reported to be somewhat different (Eckey, 450-51; Adriaens, 81; Rao *et al.*, *J. Indian chem. Soc.*, 1953, **30,** 477; Ayyar & Parekh, *Proc. Indian Sci. Congr.*, 1932, 214).

The oils from the seeds of *M. oleifera* and of *M. peregrina* Fiori syn. *M. aptera* Gaerlin. are known in the trade as Ben or Behen oil, used locally for edible purposes, illumination and in cosmetics. Ben oil was erroneously reported to be resistant to rancidity and considered particularly suitable for enfleurage and as a lubricant for fine machinery. The oil turns rancid like any other vegetable oil. It resembles olive oil and may be of some value as a constituent of non-yellowing, non-drying, plasticising alkyds [Eckey, 450; Brown, 1941, II, 60; Krishna *et al.*, *Indian For. Rec., N.S., Chem.*, 1936, **1**(1), 26; Chatfield, 81].

The cake or meal, left after the extraction of oil from the kernels, has a bitter taste. It is used as a fertilizer; it contains: crude protein, 58.93; lime (CaO), 0.40; phosphoric acid (P_2O_5), 1.09; and potash (K_2O), 0.80% (Adriaens, 82; Jamieson, 39).

Alkaloids—The root bark contains two alkaloids (total alkaloids, 0.1%), viz. moringine which is identical with benzylamine and moringinine belonging to the sympathomimetic group of bases. The latter acts on sympathetic nerve endings, producing a rise in blood pressure, acceleration of heart beat and constriction of blood vessels; it inhibits the tone and movements of involuntary muscles of the gastro-intestinal tract and relaxes bronchioles. An alkaloid, named spirochin, has been isolated from the roots; in high doses, it paralyses the vagus nerve. The root bark contains traces of an essential oil with a pungent smell, phytosterol, waxes and resins. The bark yields a coarse fibre (Chopra *et al.*, *Indian J. med. Res.*, 1932-33, **20,** 533; Ghosh *et al.*, ibid., 1934-35, **22,** 785; Chakravarti, *Bull. Calcutta Sch. trop. Med.*, 1957, **5,** 123; Chatterjee & Maitra, *Sci. & Cult.*, 1951-52, **17,** 43).

Antibiotics—Pressed juice of the leaves of the plant show strong antibacterial activity against *Micrococcus pyogenes* var. *aureus*, *Escherichia coli* and *Bacillus subtilis*. The leaf juice is bacteriostatic in a dilution of 1:1,000,000 [Scharpenseel *et al.*, *Araneta J. Agric.*, 1956, **3**(2), 46].

The roots contain an active antibiotic principle, pterygospermin ($C_{22}H_{18}O_2N_2S_2$, m.p. 15°), which is obtained as a low-melting unstable substance with a characteristic odour, soluble in organic solvents but sparingly soluble in water. It readily decomposes to benzyl isothiocyanate; it is more stable in phosphate buffer than in water. Pterygospermin (in concentrations of 0.5-3 μg./cc.) inhibits the growth of many Gram-positive and Gram-negative bacteria including *Micrococcus pyogenes* var. *aureus*, *Bacillus subtilis*, *Escherichia coli*, *Aerobacter aurogenes*, *Salmonella typhosa*, *S. enteritides*, *S. paratyphosus*, *Shigella dysenteriae*, *Mycobacterium phlei* and *M. tuberculosis* var. *hominis*. In higher concentrations (7-10 μg./cc.), it is active against fungi. It is stable in the presence of blood and gastric juice but breaks down in the presence of pancreatic juice. Its effect is counteracted by thiamine and glutamic acid

but reinforced by pyridoxine. It is toxic to experimental animals, but in low concentrations protects mice against staphylococcal infections. In view of its activity against moulds and fungi and negligible effect on seed germination, pterygospermin may find application in the preservation of fruits and vegetable and in seed treatment (Rao *et al.*, *Nature, Lond.*, 1946, **158,** 745; Rao & Natarajan, *Proc. Indian Acad. Sci.*, 1949, **29B,** 148; Kurup & Rao, *J. Indian Inst. Sci.*, 1952, **34A,** 219; Rao & Kurup, *Indian J. Pharm.*, 1953, **15,** 315; Kurup & Rao, *Indian J. med. Res.*, 1954, **42,** 85, 101; Gopalakrishna *et al.*, ibid., 1954, **42,** 97).

Gum—The stem of the tree exudes a gum which is initially white in colour but changes to reddish brown or brownish black on exposure. It is sparingly soluble in water but swells in contact with it giving a highly viscous solution. It is a polyuronide consisting of arabinose, galactose and glucuronic acid in the proportion of 10:7:2 moles; rhamnose is present in traces. The gum is locally used in calico-printing (Howes, 1949, 77; Ingle & Bhide, *J. Indian chem. Soc.*, 1954, **31,** 939; Benthall, 138).

M. concanensis Nimmo is a small tree resembling *M. oleifera* found in Rajasthan, dry hills of Konkan, Andhra Pradesh and Coimbatore. Leaves bi-pinnate, somewhat longer than those of *M. oleifera*; flowers pinkish yellow. Various parts of the tree are used in indigenous medicines in the same way as those of *M. oleifera*. The seeds yield 38% of a yellowish fatty oil with a mild pleasant odour; the characteristics of the oil are as follows: $n^{40°}$, 1.4624; acid val., 2.6; sap. val., 189.3; iod. val. (Wijs), 79.2; R.M. val., 0.57; Polenske val., 0.26; acet. val., 23.1; and unsapon. matter, 1.1% (Patel, *Curr. Sci.*, 1943, **12,** 272).

Morning Glory — *see* **Ipomoea**

MORUS Linn. (*Moraceae*)

A small genus of trees or shrubs distributed in the temperate and sub-tropical regions of the northern hemisphere. Four or five species occur in India.

Commonly known as Mulberries, a few of the *Morus* species are valued for their foliage which constitute the chief feed for mulberry silkworms (*Bombyx mori* Linn.). Some species are grown for their edible fruits and useful timber.

The identity and nomenclature of the species grown for purposes of rearing silkworms and for fruits and timber are somewhat confusing. According to earlier literature, the species found in India were designated as *M. alba*, *M. indica* Linn., *M. atropurpurea* Roxb., *M. nigra*, *M. serrata* and *M. laevigata*. Later authors have considered the first three as merely synonyms or varieties of *M. alba*, while the other three are kept distinct. Besides these, a large number of mulberry types have been introduced into India from China and Japan mainly for rearing silkworms. The introductions are reported to belong to two species, *M. multicaulis* Perr. and *M. latifolia* Poir., but some authorities regard them as a variety of *M. alba* (*M. alba* var. *multicaulis* Loud.) (Mukerji, 1899, 1-4; Bailey, 1947, II, 2069; Bailey, 1949, 337; Rehder, 1949, 147).

M. alba Linn. White Mulberry

D.E.P., V, 279, 281; C.P., 784-85, 998; Fl. Br. Ind., V, 492.

Hindi—*Tut, tutri, chinni*; Beng.—*Tut*; Mar.—*Tut, ambat*; Guj.—*Shetur*; Tel.—*Reshme chattu, pippalipandu chettu*; Tam.—*Musukette, kambli chedi*; Kan.—*Hipnerle*; Oriya—*Tuto, tuticoli*.

Kashmir—*Tut*; Punjab—*Tut, tutri*; Kumaon—*Siah tut*.

Trade—*Mulberry*.

A monoecious, occasionally dioecious shrub or moderate-sized tree with a fairly cylindrical straight bole, up to 3.0 m. high and 1.8 m. in girth. Bark dark greyish brown, rough, with vertical fissures; leaves very variable, ovate or broadly ovate, serrate or crenate-serrate, often deeply lobed; flowers inconspicuous, greenish; male spikes (catkins) lax-flowered, broadly cylindrical or ovoid, female spikes ovoid, pedunculate; fruit a syncarp consisting of many drupes enclosed in fleshy perianth, ovoid or sub-globose, up to 5.0 cm. long, white to pinkish white, purple or dark purple to black.

M. alba is indigenous to China. It is extensively cultivated throughout the plains of India and in the hilly areas of Himalayas up to an elevation of 3,300 m.; it is also grown as a road side and avenue tree. The plant is frost-hardy but liable to wind-damage. It grows rapidly in the early stages and reaches maturity at an early age; the growth rate falls off rapidly after *c.* 10 years. It coppices vigorously and pollards well.

Mulberry regenerates itself naturally from seeds which are dispersed by birds and to a limited extent by jackals and also human beings. It can be propagated artificially by seeds or cuttings. When grown close in plantations, the tree develops a long clean bole (Pearson & Brown, II, 915; Kadambi, *Indian*

For., 1949, **75,** 459 : Troup, III, 886-87 ; *Indian For.*, 1952, **78,** 361).

Numerous types of mulberry are under cultivation in various silk-producing countries of the world ; the types differ in their adaptability to various soils and climates, resistance to diseases, food value of the leaf crop for the silkworm and suitability for use as stock or scion in grafting. In Japan, the world's major silk-producing country, *c.* 700 types of mulberry are known to exist out of which 21 have been selected for extensive cultivation ; some of these types are suitable for cold climates, some for areas with severe winter and still others for areas with mild climate ; some are early, some late and some intermediate between early and late ones (Ghosh, 17 ; *Bull. cent. Silk Bd, India*, No. 13, 1951, 1 ; Krishnamurthy *et al.*, ibid., No. 15, 1951, 8).

The most important type of mulberry grown in India for rearing silk worms is *M. alba* var. *multicaulis* Loud. which is a native of China or Philippines. It is a fast-growing type adapted for cultivation as a field crop and giving high yields of large, tender and thick leaves. *M. alba* var. *atropurpurea* (*Shahtut*), also a native of China, is cultivated widely as a tree crop for its large, cylindrical, dark purple, succulent fruits ; it is also fast-growing and yields large thick leaves, which are at the same time smooth, tender and succulent. The cultivation of var. *atropurpurea* along the borders of bush plantations in Bengal has been recommended (Kadambi, loc. cit.).

Mulberry is grown on an extensive scale in various parts of India, particularly in Mysore, West Bengal and Jammu and Kashmir, for its leaf, which constitutes the food of the silkworm, and its cultivation is an integral part of the sericultural industry. It is grown either as a field crop and plants maintained in the form of bushes or as scattered trees, depending upon the race of silkworm reared. In Mysore and West Bengal, mulberry is grown as a field crop and leaves are harvested several times in the year to feed the multivoltine races of silkworm ; in Jammu and Kashmir, mulberry is grown as a tree and the leaf cropped only in one season for rearing the univoltine races of the worm. A system of growing dwarf grafted trees or 'high bushes' has been recently tried in West Bengal. Mulberry is also grown to a small extent in Punjab, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Bihar, Orissa, Assam, Manipur, Andhra Pradesh and Madras, where small quantities of silk are produced. Table 1 gives the total acreage under mulberry bushes and the number of trees in different States. The largest acreage is in Mysore, which accounts for more than 75% of the total mulberry raw silk production in the country [Ghosh, 13, 17–24, 27, 32, 36-37, 41, 219 ; Yegna Narayan Aiyer, 556, 562–63 ; Information from Central Silk Board, Bombay ; Information from Dy. Director, Industries (Sericulture), West Bengal].

Very little attention has been paid to the selection of mulberry types in India. Some trials have been carried out with various imported types, but most of them have not proved adaptable to indigenous cultivation practices. A selection, *K.M.* (*1*), evolved in Berhampore (West Bengal), yields *c.* 50% more leaves than local types and is popular in the Kollegal area of Mysore State for grafting purpose. Two strains, *Selected I* and *Selected V*, evolved in Mysore have given promising results both in respect of yield and quality of leaves (Ghosh, 17, 219-20 ; Information from Central Silk Board, Bombay).

Cultivation

Soil & Climate—Mulberry grows well under varying conditions of soil and climate. It thrives in sandy or heavy loam and black cotton soil. The average rainfall in mulberry areas is 60–100 in./annum, spread uniformly throughout the year. It does not stand water-logging or shade (Kadambi, loc. cit. ; Yegna Narayan Aiyer, 557 ; Rao, *Mysore agric. J.*, 1954, **30,** 36 ; Ghosh, 27).

Preparation of land—The land is prepared by digging or deep ploughing to a depth of 12–18 in. at the close of rains. The clods are weathered and broken, and the soil brought to a fine tilth. The crop responds to intensive application of organic and inorganic manures. Manure is applied at the time of preparing the land and after pruning the bushes ; in some areas, manuring is done also in the middle of the season. Cattle manure is generally applied at the rate of 15–25 cart loads per acre and ploughed in. Application of a mixture of 275 lb. of groundnut oil-cake and 125 lb. of ammonium sulphate per acre has been recommended under irrigated cultivation ; a part of the mixture is applied at the beginning of the season and the rest sometime later. Good yields of leaf crop are maintained by attention to the application of fertilizers at the proper time coupled with cultivation of catch crops. Well grown mulberry trees do not require any manuring (Ghosh, 29–30, 42 ; Yegna Narayan Aiyer, 557–58, 561 ; Rao, *Madras agric. J.*, 1933, **21,** 519 ; Krishnamurthy *et al.*, *Bull. cent. Silk Bd, India*, No. 15, 1951, 13).

TABLE 1—ACREAGE UNDER MULBERRY BUSHES AND NUMBER OF MULBERRY TREES† IN INDIA*

State	1951-55(av.) Acreage	No. of trees	1956 Acreage	No. of trees	1957 Acreage	No. of trees	1958 Acreage	No. of trees
Mysore	114,944	..	156,000	..	160,000	..	165,000	.
West Bengal	11,823	..	12,691	.	14,000	..	14,925	..
Jammu & Kashmir	..	2,740,000	..	3,300,000	..	3,300,000	..	3,300,000
Madras	23,885	..	1,415	..	1,838	..	2,010	..
Assam	1,590	..	1,800	..	2,214	..	2,234	..
Punjab	87	98,000	114	120,000	118	160,000	125	170,000
Uttar Pradesh	13	65,000	118	65,000	147	65,000	172	65,000
Himachal Pradesh	8	20,000	30	20,000	32	20,000	35	20,000
Others	294	..	671	..	810	..	1,014	..
Total	152,644	2,923,000	172,839	3,505,000	179,159	3,545,000	185,515	3,555,000

* Information from Central Silk Board, Bombay.
† Excluding those used for timber.

Planting material-Mulberry is propagated by seeds, cuttings, grafts or buddings. Seeds are collected from plants specially grown for the purpose and sown in shaded nursery beds within a month of their collection. The seeds are extremely small in size (12,000–13,000 seeds weigh 1 oz.) and demand care in handling. They are treated with camphor water before sowing to ward off diseases which may later affect seedlings. A thin layer of earth and ashes is spread over the seeds after sowing and the beds kept moist with frequent watering. Seeds sprout in 9–14 days according to season, and when seedlings are c. 3 in. high, the bed is thinned and weeded. For bush mulberry, seedlings 4–6 in. high are used as transplants, whereas for tree mulberry seedlings are allowed to grow to a height of 4 ft. and trained before planting in the field (Yegna Narayan Aiyer, 556, 563 ; Rao, *Mysore agric. J.*, 1954, **30**, 36 ; Ghosh, 27-29, 39 ; Kadambi, loc. cit. ; Troup, III, 887-88).

Cuttings for planting are obtained from exhausted bushes at the time of annual pruning ; branches are cut into pieces, 9-12 in. long, with three buds in each and planted immediately. In some areas in West Bengal, cuttings are tied into bundles and kept buried in soil to a depth of a few inches ; they are regularly watered and after about a month, when the buds have put forth shoots c. 2 in. long, they are taken out of the mud for planting (Yegna Narayan Aiyer, 558 ; Ghosh, 28 ; Singh, *Farm Bull., Indian Coun. agric. Res.*, No. 39, 1957, 9 ; Rao, *Madras agric. J.*, 1933, **21**, 519).

Grafts are also used for raising bush, high bush and tree mulberry. Among the several methods of grafting, the most common is root grafting. The stocks are furnished by seedlings of any type, while the scions are selected from high yielding, quick-growing types with large leaves of good feed value. Grafts give higher yields of nutritious leaves than plants raised from seedlings and cuttings, and cocoons raised on them are superior (Ghosh, 17, 32-33, 39 ; Information from Central Silk Board, Bombay ; Rao, *Mysore agric. J.*, 1954, **30**, 36).

Propagation—In Mysore and West Bengal, mulberry is cultivated mostly as bush under rainfed conditions ; only about 15% of the acreage in Mysore is under irrigation. Propagation is usually by cuttings. In Mysore, cuttings are planted in pits or furrows. Pit system of planting is considered more suitable, and is followed under both irrigated and dry cultivations, whereas the furrow system is followed only under irrigation. In dryland cultivation, cuttings are planted in prepared pits (12 in. diam. × 9 in. depth) spaced 30 in. apart in rows, the space between rows being 30 in. The planting time is July when S.W. monsoon has set in. In areas with inadequate facilities for irrigation, cuttings are planted in pits spaced 18 in. apart in rows which are set 30 in. apart. Three cuttings are planted in each pit after moistening the soil by hand watering ; an acre will require 30,000–40,000 cuttings [Ghosh, 27–28 ; Yegna Narayan Aiyer, 556, 562, 558–59 ; *Tariff Commission, Rep. on the Continuance of Protection to the Sericulture*

Industry, Govt. of India, 1958, 12; *Silk Newslett.*, 1958, **3**(3), 2].

The furrow system of planting is preferred for irrigated cultivation. Cuttings are planted in April-May in pairs at distance of 4 in., the space between furrows being 9 in. In this system the planting is very close and 70,000–80,000 cuttings are required for planting one acre (Yegna Narayan Aiyer, 558).

In West Bengal, cuttings are planted in bunches of 9, 12 or 16, each bunch being spaced 3 ft. apart either way. In dry areas, cuttings are completely buried in prepared field in a slanting position; in moist areas, the bunch of cuttings are planted in such a way that they project out of the soil. Planting is done after early showers or at any time during the rains. In Burdwan district, 1–3 sprouted cuttings are planted horizontally in pits 18 in. apart, the size of the pit being 18 in. diam. × 6 in. deep; the time of planting is November-December. In Kollegal (Mysore State) also, sprouted cuttings are planted in a similar way. They are then covered with earth and watered once a week till they take root (Ghosh, 28, 30; Rao, *Madras agric. J.*, 1933, **21**, 519).

Cuttings take root quickly and with cultivation and regular irrigation, the bushes attain a height of *c.* 2½ ft. in 6 weeks after planting. When the plants attain 3–5 ft. in height, watering is stopped under dry land cultivation, while under irrigation, watering is done twice a week. The crop is given regular weeding and interculturing (Yegna Narayan Aiyer, 559; *Bull. cent. Silk Bd, India*, No. 2, 1950, 2).

The raising of mulberry plants from seedlings is considered expensive, but the plants yield better and the quality of leaf is superior to that from bushes raised from cuttings; and attempts are now being made to replant areas which are now under cuttings-raised bushes with seedling transplants. For this purpose, seedlings are grown in beds and transplanted in pits when 4-6 in. high. When grown under irrigation, two seedlings are planted in each pit and pits are spaced 2–2½ ft. apart. Bush mulberry can be grown directly from seeds also (Krishnamurthi, 186–87; Ghosh, 29; *Bull. cent. Silk Bd, India*, No. 2, 1950, 2).

Experience has shown that grafts develop a better root system than seedlings, layerings or cuttings, and in Japan grafting has been universally adopted. In India also efforts are now being made to improve the yield and quality of leaf through the introduction of grafts produced by using any local type as stock and imported Japanese types as scion. These latter cannot be propagated vegetatively and for this reason, saplings are imported; among them the popular types are: *Kaeryo Nezumi Gaeshi, Ichinose, Ichihei, Goshyoerami, Konsen, Tsukasakuva, Roso, Tomieso, Koksu* and *Akura*. In 1956–57, 35,000 mulberry saplings were imported from Japan for distribution to various States. The Central Silk Board sanctioned during the period 1953–54 to 1957–58 a sum of Rs. 6.18 lakhs for the establishment of 22 model graft nurseries in various States and distribute improved grafts to interested planters.

Besides the imported types, a selection, *K.M.* (*1*) evolved in Berhampore, is also being used for grafting in Kollegal (Mysore State). The grafts are planted 5 ft. apart in rows, the distance between rows being 5 ft.; the number of grafts required per acre is 1,600. The grafts are trained as middling bush and are suitable for irrigated areas; more than 200 acres in Mysore State are reported to have been replanted. Attempts are now being made to raise suitable grafts for planting rainfed areas [Ghosh, 17; *Tariff Commission, Rep. on the Continuance of Protection to the Sericulture Industry*, Govt. of India, 1958, 12–13; Rao, *Mysore agric. J.*, 1954, **30**, 36; Information from Central Silk Board, Bombay; Information from Dy. Director, Industries (Sericulture), West Bengal].

Tree mulberry is grown from cuttings in the same way as bush mulberry. Saplings are trained as standard with one erect straight stem and transplanted in the field when one year old. It is more advantageous to raise tree mulberry from seedlings raised in seed beds. When seedlings are *c.* 4 ft. high, they are uprooted, and pruned low leaving only two buds; rootlets and tips of tap root are also pruned and the stump planted in a nursery 1 ft. apart in rows spaced 2 ft. apart. One shoot is allowed to grow from the pruned stem and side shoots removed. When the sapling has attained a height of 6 ft., the stem is pruned to a height of 5 ft. allowing three branches at the top. It is then ready for transplanting in the field. Tree mulberry can be raised also from grafts; only one shoot is allowed to grow from each graft and the shoot treated in the same way as in the case of seedlings. When mulberry is grown for timber purposes close planting is recommended (Yegna Narayan Aiyer, 562; Ghosh, 17, 39; *Indian For.*, 1952, **78**, 361).

Pruning and picking of leaves—Mulberry crop, whether grown as a bush, a tree or a high bush, is subject to regular pruning, in addition to periodical

stripping of leaves. Under irrigation, mulberry bushes attain a height of 3¼–4 ft. in 10 weeks, when the leaves are ready for picking. Under rainfed conditions, the first picking of leaves is done 12–17 weeks after planting. Leaves are picked at close intervals, either directly from bushes or from twigs or small branches after separating them from bushes. In the former case, as practised in Mysore, bushes are pruned to the ground level only once in a year. About 10 pickings are gathered in a year from irrigated crop, while 6 or 7 pickings are taken from rainfed crop (Yegna Narayan Aiyer, 559–60; Ghosh, 18).

In West Bengal and in some districts of Mysore, bush mulberry is pruned close to the ground just before the silkworm rearing season; leaves are stripped from branches and fed to worms. After each pruning, the field is cultivated and manured. Shoots sprout quickly and yield abundant leaves for periodical plucking. The bushes are ready for a second pruning and picking of leaves in about 6 weeks. Several crops of leaves are thus obtained in a year (Yegna Narayan Aiyer, 559; Ghosh, 31).

The best time for plucking leaves is the evening. Harvested leaves are stored in small loose heaps in a cool room and guarded against heating, fermentation and driage; moist cloth or gunny bag may be hung in the room (Yegna Narayan Aiyer, 560–61).

Bush mulberry is productive for several years, usually up to 15, after which it is pulled out and the field freshly planted. In Mysore, replanting is done usually one year after pulling out old plants, and crops like ragi or jowar are raised in the intervening period (Yegna Narayan Aiyer, 557; Ghosh, 31).

Yield—The yield of mulberry leaves varies according to the soil, moisture supply, manuring and cultural operations. In Mysore, local types grown as bushes under rainfed conditions yield 4,000–7,000 lb. of leaves per acre annually, while under irrigated conditions, the yield ranges from 10,000 to 14,000 lb. per acre per annum. In West Bengal, the annual yield of leaves per acre is estimated at 10,000 lb. The two strains, *Selected I* and *Selected V*, yield as high as 19,000–22,000 lb. per acre per year under irrigation. With the introduction of grafts of imported Japanese types, the yield of leaves has increased by 70% in Mysore. No estimates of yields from tree mulberry are available (Ghosh, 41; Yegna Narayan Aiyer, 561; Information from Central Silk Board, Bombay).

Diseases—Mildew, caused by *Phyllactinia corylea* (Pers.) Karst., affects mulberry leaves. A white powdery layer appears on the under surface and leaves get deformed or stunted and eventually turn brown and dry up. The disease is checked by dusting the bushes with sulphur at the rate of 15 lb./acre or spraying with potassium sulphide. Plucking and destroying affected leaves are suggested as control measures [Butler, *Mem. Dep. Agric. India, Bot.*, 1909, **2**(8), 11; *Indian J. agric. Sci.*, 1950, **20**, 107; Vasudeva, *Indian Fmg, N.S.*, 1956–57, **6**(7), 51; Yegna Narayan Aiyer, 565–66].

In Kashmir, tree mulberry suffers from a disease caused by *Thyrostroma mori* (Nomura) Hoehnel syn. *Coryneum mori* Nomura, resulting in considerable reduction in leaf output. Nursery stock is also affected. The disease is localised and attacks branches near the base. The fungus gains entrance through wounds caused by pruning or breaking off of branches and through injuries caused by frost and snow. As control measures, diseased wood is cut off and cut surfaces painted with a disinfectant; prunings from diseased trees are burnt [Butler, *Mem. Dep. Agric. India, Bot.*, 1909, **2**(8), 1; Yegna Narayan Aiyer, 566; Butler, 67].

Mulberry leaf-spot, caused by *Phleospora mori* (Lev.) Sacc. syn. *Septogloeum mori* (Lev.) Briosi & Cav., manifests itself as angular spots on young leaves; the spots which are reddish with a pale brown centre develop into pustules and leaves drop prematurely. Plucking and burning of affected leaves reduce the spread of disease. Spraying with Bordeaux mixture is effective in controlling the disease in nurseries [*Indian J. agric. Sci.*, 1950, **20**, 107; Butler, *Mem. Dep. Agric. India, Bot.*, 1909, **2**(8), 11; Yegna Narayan Aiyer, 566].

Mulberry trunk rot is caused by *Polyporus hispidus* (Bull.) Fr. The fungus affects the trunk and also larger branches which dry up and die. Cutting off of affected parts is recommended as a control measure [Butler, *Mem. Dep. Agric. India, Bot.*, 1909, **2**(8), 14].

Showmia disease, characterized by the development of rusty brown patches on leaves, affects mulberry plants in certain parts of West Bengal. The causal agent has not been identified. Affected leaves are poisonous to silkworms and cause flacherie. Heavy rain favours the onset of disease and diseased leaves show an abnormal deficiency of potash and low protein and sugar contents (Ghosh, 45; Yegna Narayan Aiyer, 565).

Other fungal diseases reported to attack mulberry are : rust (*Aecidium mori* Barclay), bronze canker [*Cytospora atra* (Bon.) Sacc.], stem rot (*Diplodia butleri* Syd.), white sap and heart rot [*Ganoderma applanatum* (Pers.) Pat. and *G. lucidum* (Leyss.) Karst.], white spongy sap rot [*Polyporus tulipiferae* (Schweinitz) Overholts] and butt rot [*Trametes badia* (Berk.) Cooke] (*Indian J. agric. Sci.*, 1950, **20**, 107 ; Wlth India—Raw Materials, IV, 78 ; Bakshi *et al.*, *Indian For.*, 1956, **82**, 449).

Pests—In Murshidabad, Malda and Birbhum districts (West Bengal), mulberry plants are sometimes affected by a serious pest and the resulting disease is known locally as *Tukra*. The disease is characterized by severe curling and crinkling of leaves of apical shoots and swelling and twisting of apical internodes. The causal agent is an insect, *Phenococcus hirsutus* Gr., which sucks the sap of stem, leaf and petiole. Spraying with nicotine sulphate affords effective control (Raichoudhury, *Rev. Ver a Soie*, 1958, **10**, 315 ; Ghosh, 44 ; Yegna Narayan Aiyer, 565 ; Misra, *Bull. agric. Res. Inst. Pusa*, No. 109, 1921, 610).

Longicorn beetle (*Sthenias griesator* F.), also called Stem Girdler beetle, occasionally causes serious damage to mulberry. It bores tunnels or girdles the stem a few inches above the ground, killing the growth above the injury. Hand-picking of insects and destroying them and cutting off affected portions are recommended as control measures (Ghosh, 46 ; Subramaniam, *Ind-Com J.*, 1950, **5**, 180 ; Yegna Narayan Aiyer, 565).

Scale insects (*Ceroplaster* spp.) affect stem and branches of tree mulberry ; they suck the sap and ultimately kill the plant. Spraying or smearing with soap solution or with rosin compound solution affords control (Subramaniam, loc. cit. ; Ghosh, 45).

Borers sometimes damage stems and roots of mulberry. Stem borers are found mostly at the junctions of branches with the main stem. They tunnel inside the sapwood and affected branches dry up. The pest is controlled by squirting kerosene oil into the hole as a result of which the borer is driven to the entrance of the hole where it dies (Yegna Narayan Aiyer, 565).

Tenebrinoid beetle, *Gonocephalum planatum* Walker, causes damage to mulberry seedlings in West Bengal. Dusting with Gammexane (15 lb./acre) affords protection (Banerjee & Chatterjee, *Sci. & Cult.*, 1952–53, **18**, 36).

Other minor pests of mulberry are aphids, thrips (*Pseudodendrothrips ornatissimus* Schmutz.), hairless caterpillar (*Diacrisia obliqua*) and weevils (*Apion* sp.) which affect leaves and white grubs (*Lachnosterna* spp.) which affect roots of seedlings and young plants. Termites cause damage to newly planted grafts and cuttings. Mole rats (*Cannomys castaneus* Blyth.) eat mulberry roots killing entire bushes and sometimes even well-grown trees (Yegna Narayan Aiyer, 565 ; Ghosh, 46–49).

Uses and Composition

Mulberry is grown extensively for leaves used for rearing silkworms. Fruits are eaten and the wood is valued for the manufacture of sports goods.

Leaves—Young leaves which have attained full size are best suited for feeding silkworm larvae. The composition of leaves varies with variety, degree of maturity and the type of soil in which the plants are grown. The protein content of leaves decreases and the carbohydrate content increases with the maturity of leaves ; fibre, fat and ash constituents also increase. Young leaves are more acidic than older ones. Analysis of leaves collected from different localities in India gave the following ranges of values (dry basis): crude protein, 16.0–39.0 ; soluble sugars, 7.6–26.0 ; ash, 8.0–17.0 ; calcium (CaO), 0.7–2.7 ; and iron (Fe_2O_3), 0.05–0.12%. Table 2 gives the analytical values of samples collected from Kashmir and Bengal ; the composition of leaves of the Japanese "Roso" type is given for comparison (Yegna Narayan Aiyer, 566–67 ; *Chem. Abstr.*, 1941, **35**, 3288).

TABLE 2—COMPOSITION OF MULBERRY LEAVES FROM DIFFERENT SOURCES*

(%, dry wt. basis)

	Kashmir	Bengal	'Roso' from Japan
Crude protein	28.80	28.40	18.00
Soluble sugars	13.60	12.20	11.30
Phosphorus (P_2O_5)	1.40	1.36	0.65
Potassium (K_2O)	3.60	3.92	2.00
Calcium (CaO)	2.40	2.40	1.40
Magnesium (MgO)	0.72	0.72	0.25
Aluminium (Al_2O_3)	1.80	1.60	0.80
Iron (Fe_2O_3)	0.06	0.05	0.26
Silica (SiO_2)	2.00	1.80	2.60
Sulphur (SO_3)	0.56	0.54	0.30

*Yegna Narayan Aiyer, 566.

The relation between the composition of mulberry leaves fed to larvae and the resultant silk production has been extensively investigated. It has been found that accumulation of protein in larvae depends largely on the concentration of carbohydrates in the leaves. The maximum growth of larvae occurs when they are fed on leaves containing 3-4% sugars at the first instar period and 4-5% at the second instar period. When the leaf is low in soluble carbohydrates, addition of sucrose produces favourable results both as regards yield and quality of silk (Thorpe, VIII, 243; *Chem. Abstr.*, 1943, **37,** 1782).

The preferential food value of mulberry leaf for silkworm larvae is attributed to the presence in it of 3 stimulant factors, viz. an attractant, a biting factor and a swallowing factor. The substances which attract the larvae to the leaves have been identified as citral, linalyl acetate, linalol, terpinyl acetate and hexenol, the first 3 being more effective than the rest. β-Sitosterol (*c.* 0.2% in leaves), along with some sterols and a water-soluble substance, is the main factor which stimulates the biting action: the amount of food eaten by larvae is controlled by the concentration of β-sitosterol. The third factor which stimulates continuous swallowing of leaves by larvae is present in the methanol-insoluble, but water-soluble, fraction. The absence of any one of these factors inhibits feeding by larvae. The leaves of soybean and tea contain the first factor; they attract the larvae but are not eaten. The larvae exhibit a weak chemotaxis to the leaves of fig and lettuce and consume them when hungry: these leaves, however, do not support normal growth (Watanabe, *Nature Lond.*, 1958, **182,** 325; Hamamura, ibid., 1959, **183,** 1746; Hamamura & Naito, ibid., 1961, **190,** 879; Hamamura *et al.*, ibid., 1961, **190,** 880).

A prolamin has been separated from alcoholic (alkaline) extracts of mulberry leaves: it forms the principal protein of the leaves. The nitrogen distribution in a preparation containing 12.64% N was as follows: HCl insol. N, 0.50; humin N, 0.45; amide N, 0.96; diamino acid N (arginine N, 0.89; histidine N, 0.49; lysine N, 0.35; cystine N, 0.01), 1.74; and monoamino acid N, 7.89%. Protein preparations from young mulberry leaves form an excellent supplement to protein-deficient diets (*Chem. Abstr.*, 1936, **30,** 7147; 1952, **46,** 10325).

Non-protein nitrogen accounts for *c.* 22% of the total nitrogen in young leaves and *c.* 14% in mature leaves. The amino acids identified in the free form are: phenylalanine, leucine, valine, tyrosine, proline, alanine, glutamic acid, glycine, serine, arginine, aspartic acid, cystine, threonine, sarcosine, γ-aminobutyric acid, pipecolic acid and 5-hydroxy pipecolic acid (*Chem. Abstr.*, 1952, **46,** 10325; 1953, **47,** 7681; 1958, **52,** 17407).

The leaves are a good source of ascorbic acid, 200-300 mg./100 g., of which over 90% is present in the reduced form. They contain also carotene, vitamin B_1, folic acid, folinic acid and vitamin D. The presence of glutathione in leaves has been reported (*Chem. Abstr.*, 1951, **45,** 2544; 1940, **34,** 4863; 1954, **48,** 9485; 1938, **32,** 9200; Wehmer, I, 237).

Mulberry leaves are rich in calcium; the mineral constituents present in the leaves are given in Table 2; copper, zinc, boron and manganese occur in traces. Phytate phosphorus accounts for 18.2% of total phosphorus (Thorpe, VIII, 244; *Chem. Abstr.*, 1954, **48,** 232; Gowda *et al.*, *Indian J. med. Res.*, 1955, **43,** 603).

Volatile constituents identified in steam-distillates of mulberry leaves are: *n*-butanol, β-γ-hexenol, methyl-ethyl acetaldehyde, *n*-butylaldehyde, isobutylaldehyde, valeraldehyde, hexaldehyde, α-β-hexenal, acetone, methyl-ethyl ketone, methyl-hexyl ketone, butylamine and acetic, propionic and isobutyric acids. Other constituents reported to be present in the leaves are: calcium malate, succinic and tartaric acids, xanthophyll and isoquercitrin (quercetin 3-glucoside, $C_{21}H_{20}O_{12}$, m.p. 220-22.5°) and tannins; adenine, choline and trigonelline bases are present in young leaves (Watanabe, *Nature, Lond.*, 1958, **182,** 325; *Chem. Abstr.*, 1954, **48,** 2269; Heilbron & Bunbury, III, 124; Wehmer, I, 237; Kalyankar *et al.*, *Curr. Sci.*, 1952, **21,** 220; *Chem. Abstr.*, 1931, **25,** 2758; 1935, **29,** 1644).

Mulberry leaves are sometimes eaten as vegetable. They are also useful as cattle fodder; they are nutritious and palatable, and are stated to improve milk yield when fed to dairy animals. Analysis of leaves (from U.P.) gave the following values (dry wt. basis): protein, 14.0; ether extr., 6.8; N-free extr., 49.7; total ash, 13.8; calcium (CaO), 2.74; and phosphorus (P_2O_5), 0.45%. Feeding experiments have shown that up to 6 kg. of leaves per day can be fed to milch cows without adversely affecting the health of animals or the yield and butter content of milk (Burkill, II, 1498; Datta, *Sci. & Cult.*, 1941-42, **7,** 242; Lander, *Misc. Bull., Indian Coun. agric. Res.*, No. 16, 1942, 83; *Chem. Abstr.*, 1939, **33,** 2240).

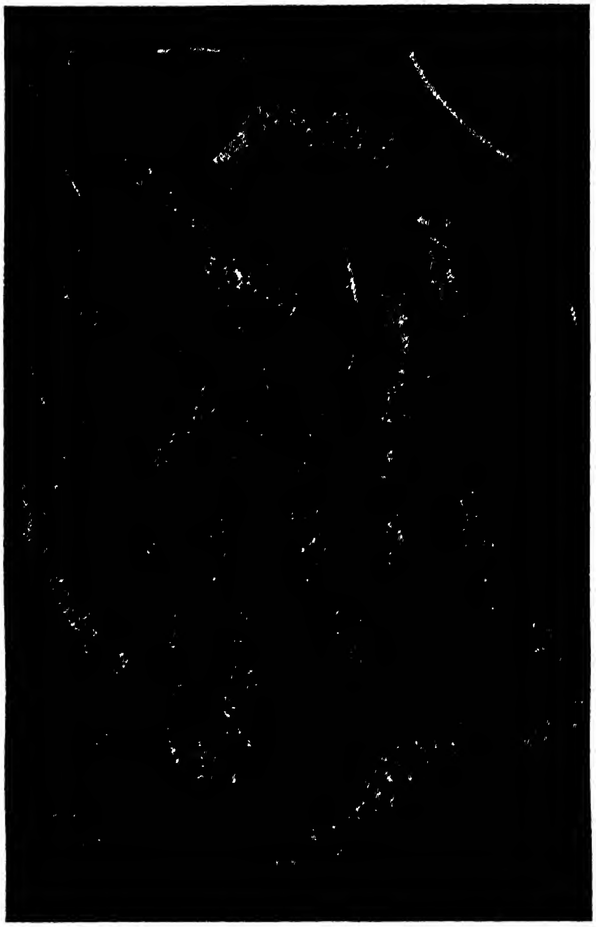


FIG. 166. MORUS ALBA—FRUITS

Fruits—The fruits of *M. alba* are eaten fresh or made into juice, stews and tarts; they may be squashed and fermented to yield spirituous liquors. Analysis of fruits (from Coonoor) gave the following values: moisture, 87.5; protein, 1.5; fat, 0.4; carbohydrates, 8.3; fibre, 1.4; and mineral matter, 0.9%; calcium, 80 mg.; phosphorus, 40 mg.; and iron, 1.9 mg./100 g.; carotene (as vitamin A), 174 i.u.; thiamine, 9 μg.; nicotinic acid, 0.8 mg.; riboflavin, 184 μg.; and ascorbic acid, 13 mg./100 g. The fruits contain a flavonoid, possibly eriodictyol [Macmillan, 271; Belavady & Balasubramanian, *Indian J. agric. Sci.*, 1959, **29**(2 & 3), 151; Ganju & Puri, *Indian J. med. Res.*, 1959, **47**, 563].

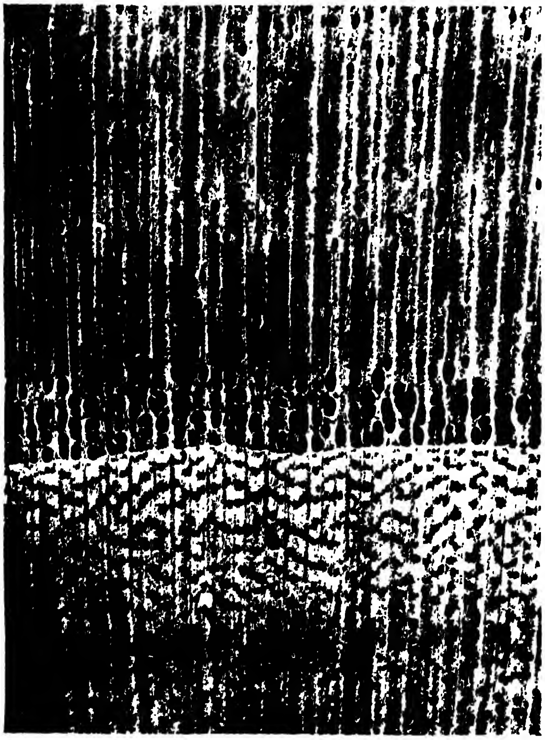
The seeds (c. 2 mm. long) contain 25–35% of a yellow drying oil with the following characteristics: sp. gr.$^{15°}$, 0.924–0.926; sap. val., 190–192; iod. val., 140–144; and R.M. val., 0.10–0.35. Liquid fatty acids constitute the major part (80–90%) of the total fatty acids of the oil (Mensier, 380).

Wood—The wood of *M. alba* is much valued by the sports goods industry on account of its elasticity and flexibility when steamed; it is considered to be as good as ash (*Fraxinus excelsior*) for this purpose. The sapwood is white to yellowish white; heartwood bright yellowish brown or golden brown, darkening after exposure. It is light to moderately heavy (sp. gr., c. 0.63; wt., 36–46 lb./cu. ft.), straight-grained, medium coarse- and somewhat uneven-textured, moderately hard to hard and elastic; it is not liable to split but shows a tendency to warp; this can be reduced by quartering the logs and excluding the heart-centre from scantlings. The best results are obtained by storing logs or quartered logs for some months before final conversion, care being taken to protect the ends to slow down drying. The timber is moderately durable under cover; graveyard tests indicate a durability of 2½ years (Pearson & Brown, II, 915, 917–18; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 55; Trotter, 1944, 141; Purushotham *et al.*, *Indian For.*, 1953, **79**, 49).

The wood is easy to saw, work, turn, bend and finish; it peels well on a rotary lathe. It seasons well with care and can be kiln-seasoned without difficulty or degrade. It does not require antiseptic treatment. The data for the comparative suitability of mulberry timber, expressed as percentages of the same properties of teak, are: wt., 100; strength as a beam, 80; stiffness as a beam, 75; suitability as a post, 75; shock-resisting ability, 155; retention of shape, 65; shear, 145; and hardness, 115 (Pearson & Brown, II, 917–18; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 55, Sheet No. 14; Trotter, 1944, 141–42).

Mulberry wood is used chiefly for hockey sticks, tennis and badminton rackets, racket presses, cricket bats and stumps, and other sports goods. The wood is converted green, steam bent and dried in the bent form, tightly held in clamps; sapwood is preferred to heartwood. The wood is suitable for house building, agricultural implements, furniture and turnery, especially picker arms, bobbins and tool handles. It is also useful for spokes, poles, shafts and bent parts of carriages and carts. It affords a medium grade fuel wood (4,371–4,773 cal.) (Pearson & Brown, II, 918; Trotter, 1944, 141; *Indian For.*, 1952, **78**, 369; 1948, **74**, 280).

The wood contains tannin; extracts prepared from



F.R.I., Dehra Dun. Photo: S. S. Ghosh

FIG. 167. MORUS ALBA—TRANSVERSE SECTION OF WOOD (×10)

wood (tannin content, c. 32%) are considered suitable for tanning and colouring purposes. Morin (pentahydroxyflavone, $C_{15}H_{10}O_7$, m.p. 286–88°), maclurin (pentahydroxybenzophenone, $C_{13}H_{10}O_6$, m.p. 220–22° anhyd.) and 2,4,6,4′-tetrahydroxy benzophenone, have been reported as present in the branchwood of *M. alba* by some workers. This has not been confirmed by subsequent work. Heartwood contains 2,4,3′,5′-tetrahydroxystilbene ($C_{14}H_{12}O_4$, m.p. 203°; yield, 2%), along with small amounts of dihydromorin (m.p. 226–28°), dihydrokaempferol (m.p. 227–28°) and dihydroquercetin (*Chem. Abstr.*, 1941, **35**, 3288; Laidlaw & Smith, *Chem. & Ind.*, 1959, 1604; Heilbron & Bunbury, III, 535, 200).

Bark—The stem bark of *M. alba* is fibrous and has been employed in China and Europe for paper making. The bark may be stripped from waste branches, after separating the leaves for silkworm feeding, and worked into paper pulp. Digestion with 14% caustic soda solution and bleaching with 5% active chlorine gives a product equal in quality to the pulp obtained from rags. A fibre suitable for use in the textile industry has been extracted from the bark by retting. The fibre (av. length, 2.5 cm.) is white and soft with silk-like feel. The twigs are used as binding material and for making baskets (Burkill, II, 1498; *Chem. Abstr.*, 1934, **28**, 5232; 1935, **29**, 7072; 1944, **38**, 3135; Krishnaswamy, 134).

Mulberry leaves are considered diaphoretic and emollient. A decoction of leaves is used as a gargle in inflammations of the throat. The fruit is cooling and laxative; it is used for sore throat, dyspepsia and melancholia. The root is reported to possess anthelmintic and astringent properties. The bark is used as a purgative and vermifuge. Aqueous and alkali extracts of leaves and stems are active against Gram-positive bacteria and yeasts. The stem contains steroidal sapogenins; α-amyrin is present in the bark (Quisumbing, 240; Burkill, II, 1498; Kirt. & Basu, III, 2307–08; Nickell, *Econ. Bot.*, 1959, **13**, 281; Anzaldo *et al.*, *Philipp. J. Sci.*, 1957, **86**, 233; *Chem. Abstr.*, 1936, **30**, 6786).

M. laevigata Wall. ex Brandis

D.E.P., V, 284; Fl. Br. Ind., V, 492.

HINDI—*Tut*.

KUMAON—*Tut, shah-tut, siyah-tut*; NEPAL—*Kimbu*; ASSAM—*Bola*; KHASI—*Dieng-bylliet*; GARO—*Rokseng*; LUSHAI—*Hmubelbing*; ABOR—*Ayumasing*.

TRADE—*Bola*.

A tree found in the outer Himalayas from Kumaon eastwards to Assam up to an altitude of 1,500 m. and in Andaman Islands; it attains a height of 30 m. or more and a girth of 4.5 m. in eastern Himalayas, but the size is much smaller in western Himalayas. Bark brownish grey when young, dark brown, rough, splitting in square flakes in mature trees; leaves ovate or ovate-cordate, finely serrate or serrulate; flowers small, in spikes 10–12.5 cm. long; fruit long, cylindrical, yellowish white, sweet or insipid.

M. laevigata occurs in evergreen and mixed deciduous forests in moist localities. It grows on a wide range of geological formations and thrives best on well-drained, light alluvial soil and also on silt. It is a light-demander and fairly frost-resistant; it coppices and pollards satisfactorily. Natural regeneration is not common. Artificial reproduction is possible by direct sowing or transplanting seedlings from the nursery; stump planting gives good results. The rate of growth varies according to locality; it is rapid in the first few years, but falls off gradually (Kadambi, *Indian For.*, 1952, **78**, 176; Pearson & Brown, II, 920).

The sapwood of *M. laevigata* is white to yellowish white; heartwood bright yellowish or golden brown,

darkening appreciably and becoming duller with age. It is light to moderately heavy (sp. gr., 0.59; wt., 38 lb./cu.ft.), straight-grained, medium coarse- and even-textured, moderately hard to hard, strong and elastic. It is probably stronger than *M. alba*. It seasons well and is durable under cover. It saws well, works to a smooth surface and takes a fair polish. It has fairly good steam-bending properties (Pearson & Brown, II, 922; *Indian For.*, 1957, **83**, 738).

The wood is largely used in Darjeeling, Assam and Burma for house building and for making oars, stocks, spokes, poles, shafts of carriages and carts, yokes, furniture and planking. It is suitable for low grade plywood and for panelling, carving and turnery, tea boxes and toys; it is also used for making tennis rackets. Large quantities of the timber are available from Goalpara, Kamrup and North-eastern parts of Assam: fair supplies are available from Bengal (Pearson & Brown, II, 923, 920; Kadambi, *Indian For.*, 1952, **78**, 176; Howard, 376; Gamble, 636; IS: 399-1952).

The fruit of the plant is eaten, though insipid; it is excellent when stewed with sugar. The milky juice exuded by the plant is used as a plaster for sores (Bor, 137; Fl. Assam, IV, 275).

M. nigra Linn. BLACK MULBERRY

Bailey, 1949, 337; Kirt. & Basu, Pl. 891B.

A medium or small-sized tree, 6–9 m. high, native of West Asia and cultivated in many countries for its edible fruits. Leaves broadly ovate-cordate, usually undivided, sometimes 2–5 lobed; flowers dioecious or monoecious; fruit (syncarp) ovoid to oblong, 2.0–2.5 cm. long, purple to black, juicy, edible.

M. nigra is cultivated in Kashmir; it is also grown in Darjeeling. It is less hardy to cold and prefers a warm, well-drained loam soil. Propagation is by cuttings or budding; shield, ring and flute budding are commonly adopted. The trees are pruned to a height of 3–3½ ft. from the ground level in December or January when leaves have been shed. This encourages vigorous growth and production of large-sized fruits. The tree flowers in February–March and fruits mature by May–June. A fully developed tree yields 20–30 lb. of fruits per year (Chittenden, III, 1322; Duthie, III, 138; Information from Central Silk Board, Bombay; Hayes, 365; Singh, *Farm Bull., Indian Coun. agric. Res.*, No. 39, 1957, 9).

Ripe fruits of *M. nigra* are sweet and well-flavoured: they are eaten fresh or made into jam, jelly and sherbet. In Europe, a wine is prepared from the fruits. Analysis of ripe fruits (from Coonoor) gave the following values: moisture, 85.5; protein, 0.7; fat, 0.4; carbohydrates, 12.2; fibre, 0.8; and mineral matter, 0.4%: calcium, 60 mg.; phosphorus, 20 mg.; and iron, 2.6 mg./100 g.: carotene (as vitamin A), 16 i.u.; thiamine, 58 μg.; nicotinic acid, 0.2 mg.; riboflavin, 92 μg.; and ascorbic acid, 10 mg./100 g. Reducing sugars constitute the bulk of carbohydrates. The fruit contains malic acid, citric acid, pectin, mucilage and a colouring matter [Hayes, 366; Miller *et al.*, 106; Singh, *Punjab Fmr*, 1952, **4**, 275; Belavady & Balasubramanian, *Indian J. agric. Sci.*, 1959, **29**(2 & 3), 151; Khan & Chughtai, *Pakist. J. sci. Res.*, 1956, **8**, 73; Wehmer, I, 237].

The leaves of *M. nigra* are inferior to those of *M. alba* for feeding silkworms. The fruit is considered refrigerant and laxative. The juice forms a grateful drink during convalescence after febrile diseases; it checks thirst and cools the blood. The bark is purgative and vermifuge. Root bark contains calcium malate; the bark of branches contains tannins, phlobaphenes, a sugar, a phytosterol (m.p. 132°), ceryl alcohol, fatty acids and phosphoric acid. An infusion of leaves causes a drop in blood sugar, sometimes diuresis, and a reduction of arterial pressure; it has no effect on glucosuria (Chittenden, III, 1322; Kirt. & Basu, III, 2309; Wehmer, I, 237; *Chem. Abstr.*, 1931, **25**, 3032; 1935, **29**, 1507).

M. serrata Roxb. HIMALAYAN MULBERRY

D.E.P., V, 284; III, 430; Fl. Br. Ind., V, 492.

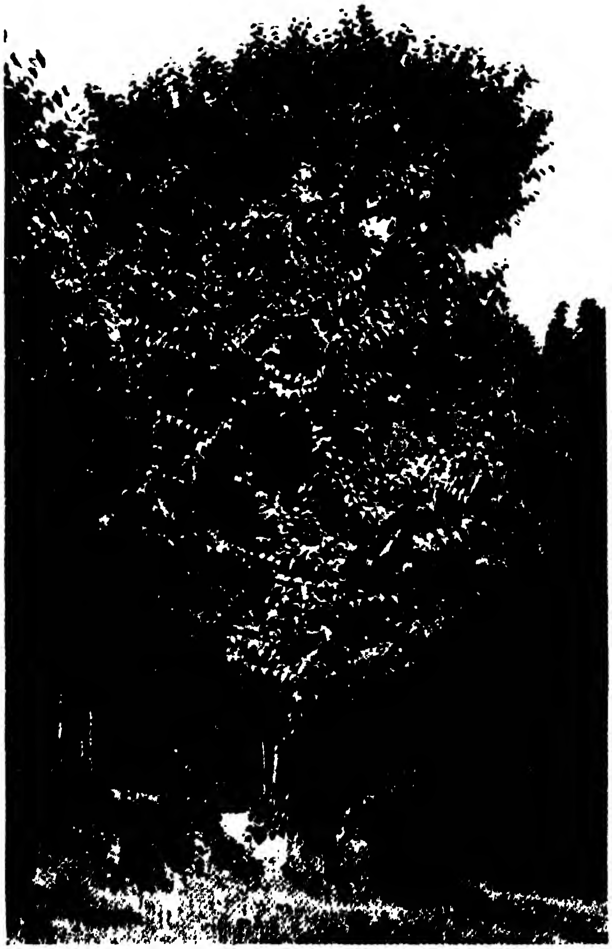
HINDI—*Kimu, himu*.

PUNJAB—*Karum, kimu, karttut*; DEHRA DUN—*Himu, tuti*; KHASI—*Dieng-soh-tungkhar*.

A large tree, 18–21 m. high, with a clean cylindrical bole 3.5 m. long, found from Trans-Indus to Kumaon, principally in the inner ranges of Himalayas at altitudes of 1,200–2,700 m. Bark reddish or greyish brown, smooth when young, rough with vertical fissures in old trees; leaves broadly ovate-cordate, acuminate, often lobed; flowers dioecious in spikes: male spikes, 2.5–5.0 cm. long, female much shorter; fruit long, purple, sweet, edible.

M. serrata is the common mulberry of the Himalayas. It is frequently cultivated in hill stations and sometimes planted as a shade tree. Propagation is done from seeds and cuttings. The tree coppices well and produces root suckers (Troup, III, 890–91; Parker, 474).

The tree yields a hard tough timber. The sapwood is white to pale yellowish white: heartwood



F.R.I., Dehra Dun. Photo: T. V. Dent

FIG. 168. MORUS SERRATA—TREE

light yellow to yellowish brown, ageing to a rich chocolate brown. It is heavy (sp. gr., 0.67 ; wt., 33–52 lb./cu.ft.), moderately strong, straight-grained and coarse- and uneven-textured. It seasons and saws well and is easy to work, turn, bend and finish. It is moderately durable under cover ; graveyard tests indicate a life of 2–3 years. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 95 ; strength as a beam, 70 ; stiffness as a beam, 75 ; suitability as a post, 60 ; shock-resisting ability, 130 ; retention of shape, 80 ; shear, 115 ; and hardness, 90 (Pearson & Brown, II, 918, 920 ; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 55, Sheet No. 14 ; Purushotham *et al., Indian For.*, 1953, **79**, 49).

The wood is used for furniture and carving, toys, sporting requisites, troughs, agricultural implements and cheap types of guns and rifles. It makes ornamental panelling (Pearson & Brown, II, 920 ; Gamble, 636 ; *Industry, Calcutta*, 1950, **41**, 299 ; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 55).

The tree is lopped for fodder. Leaves are used for feeding silkworms in Khasi and Jaintia hills (Troup, III, 890 ; Fl. Assam, IV, 274).

M. australis Poir. syn. *M. acidosa* Griff. is a shrub or small tree found in Assam and Khasi hills. It is often cultivated for the leaves used for rearing silkworms. Ripe fruits are eaten (Fl. Assam, IV, 273).

MOSCHOSMA Reichb. (*Labiatae*)

A small genus of annual or perennial herbs distributed throughout the tropics of the Old World. One species occurs in India.

M. polystachyum Benth.

Fl. Br. Ind., IV, 612 ; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 35.

A herbaceous erect, much-branched annual, 60–100 cm. high, found in wet places in Bihar, West Bengal, Carnatic from Nellore southwards to S. Travancore, Konkan and Gujarat. Leaves ovate, irregularly crenate-serrate ; flowers small, pale pink or lilac, in racemes.

The crushed leaves are used as an external application to sprains. A decoction of leaves is given as a sedative for epilepsy, palpitation of heart, neuralgia and convulsions ; it causes sores in the mouth. In West tropical Africa, the juice of the plant is used in curing headache in children (Burkill, II, 1498 ; Dalziel, 462).

Mosquitoes — *see* **Insects and Insect Pests**

Moss, Club — *see* **Lycopodium**

Mother-of-Pearl — *see* **Molluscs**

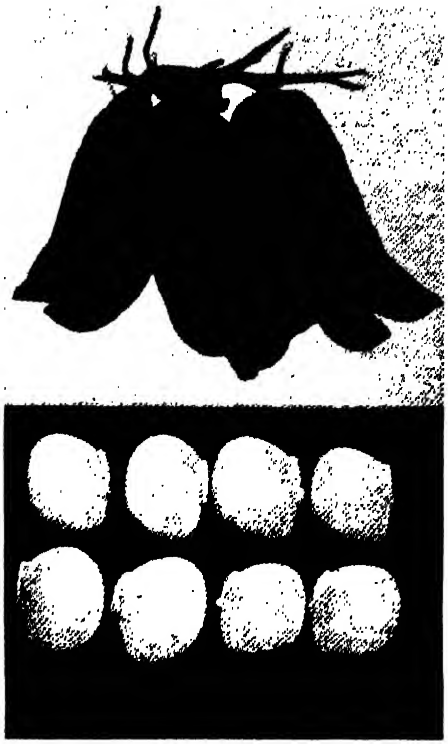
Motherwort — *see* **Leonurus**

Mouton — *see* **Fur and Fur-bearing Animals**

MUCUNA* Adans. (*Leguminosae*)

A genus of annual or perennial twining herbs or shrubs, distributed in the tropics and sub-tropics. About 15 species occur in India. Some of them are grown for forage, green manuring, soil cover or ornament ; young pods of some are used as vegetable.

* The genus has been conserved against *Stizolobium* P. Br.



Dep. Agric. Bombay. Photo : M. V. Thombre

FIG. 169. MUCUNA COCHINCHINENSIS—FRUITS AND SEEDS

M. cochinchinensis Cheval. syn. *M. nivea* (Roxb.) DC. ; *Stizolobium niveum* Kuntze LYON BEAN

D.E.P., V, 285 ; Fl. Br. Ind., II, 188.

BENG. *Khamach.*

MUNDARI—*Kursi.*

An annual twining herb with white or pale purple flowers and glabrescent pods cultivated in Bengal and Bihar for its edible pods and seeds. Pods 10–15 cm. long, downy when young, wrinkled and destitute of down when ripe ; seeds 6–8, oval, smooth, ash-coloured. This species hybridizes with *M. deeringiana* and *M. pruriens.*

M. cochinchinensis is considered useful for fodder, cover crop or green manure. It grows vigorously and makes a dense cover in 60–70 days after sowing ; sown in July, it yields 180–200 md. of green fodder per acre. It grows well also in mixture with maize or jowar and yields on an average 40–50% more than a comparable stand of maize-cowpea mixture [Burkill, II, 1502 ; Thombre, *Curr. Sci.*, 1958, **27**, 498 ; Dabadghao & Gandhi, *Indian Fmg, N.S.*, 1954–55, **4**(6), 16].

The fleshy and tender fruits of the plant are valued as vegetable ; they are cooked and eaten after removing the velvety skin. The seeds contain (dry matter basis): carbohydrates, 55.8 ; albuminoids, 27.5 ; and fat, 3.6% (Burkill, II, 1502).

M. deeringiana (Bort) Merrill syn. *Stizolobium deeringianum* Bort FLORIDA OR GEORGIA VELVET BEAN

Bailey, 1949, 576.

PUNJAB *Makhmali sem.*

A herbaceous, pubescent, trailing or twining annual, up to 18 m. or more in length, introduced into India as fodder plant. Leaves tri-foliolate : leaflets ovate or rhomboid, 5–15 cm. long ; flowers purple, in pendent racemes ; pods turgid, 5–7.5 cm. long, ridged, densely covered with black pubescence ; seeds 3–5 in a pod, nearly globular, usually speckled, streaked and marbled brown or black : pure grey or black seeds not uncommon.

M. deeringiana is considered to be a native of Asia. It was introduced into America by way of Mauritius whence it has spread to many tropical countries and grown as fodder, green manure and cover crop ; seeds

I.A.R.I., New Delhi

FIG. 170. MUCUNA DEERINGIANA—FRUITING BRANCH

I.A.R.I., New Delhi

FIG. 171. MUCUNA DEERINGIANA—SEEDS

from unripe pods are used as vegetable [Burkill, II, 1502; Hill, 343; Use of Leguminous Plants, 227; Dabadghao & Gandhi, *Indian Fmg, N.S.*, 1954–55, **4**(6), 16; Roberts & Kartar Singh, 473].

The plant can be grown in any soil but prefers medium to light loam. It thrives best under warm moist conditions in areas where rainfall is plentiful or irrigation is possible. In India, it is grown as a *kharif* crop either alone or mixed with maize or jowar. Seeds are sown in lines, 3–4 ft. apart, for raising a seed crop; they are sown broadcast, at the rate of 30–40 lb. of seeds per acre for fodder or cover crop. Seeds germinate in about a week. The crop does not require much attention and it responds well to phosphatic fertilizers drilled in at the time of sowing; inoculation of soil with bacterial cultures is reported to be helpful. By its vigorous growth, it smothers weeds and provides an ideal cover for preventing soil erosion; it can be ploughed in as green manure. Analysis of green material gave the following values: nitrogen, 0.56; potassium, 0.37; and phosphorus, 0.06% [Singh, *Indian Fmg, N.S.*, 1954–55, **4**(9), 13; Use of Leguminous Plants, 227; Whyte *et al.*, 324; Roberts & Kartar Singh, 473; Lander, 158; Dabadghao & Gandhi, loc. cit.; Morrison, 1035].

The seed crop is ready for harvest in c. 6 months from sowing. A yield of 8–12 md./acre of seeds and 30–40 md./acre of hay is reported (Singh, loc. cit.).

When grown for forage, the crop is ready for harvesting in 90–100 days after sowing. A yield of 100–200 md./acre of green fodder is reported. Experimental cultivation at the Indian Agricultural Research Institute, New Delhi, has shown that maize-mucuna mixture yields 45–50% more fodder than the more usual maize-cowpea mixture; it can also be grown in mixture with *Euchlaena mexicana* (Lander, 158; Singh, loc. cit.; Dabadghao & Gandhi, loc. cit.; Roberts & Kartar Singh, 473).

The plant may be grown pure and used in pasture or fed as hay. It provides good fodder for cattle and sheep, but not for pigs; it is regarded as excellent feed for farm animals, particularly young growing stock. Analysis of green forage from Punjab gave the following values (dry basis): protein, 15.14; ether extr., 2.13; N-free extr., 48.53; fibre, 19.27; and ash, 14.93%; digestible protein, 10.66; digestible carbohydrates, 49.64; digestible ether extr., 1.37; and total digestible nutrients, 63.38%; nutritive ratio, 4.9; it is rich in calcium, phosphorus, iron and iodine (Piper, 603; Nicholls & Holland, 477; Morrison, 330; Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1952, 16, 26; Lander, 159).

Dry pods and seeds are a good source of protein and used in rations for dairy cows and for fattening cattle and sheep; for feeding dairy cows, the seeds are ground into meal or soaked in water. The pods contain about one-half as much protein as cottonseed meal, but supply an almost equal amount of total digestible nutrients. Analysis of whole pods and seeds gave the following values: *whole pods*—moisture, 10.0; protein, 18.1; fat, 4.4; N-free extr., 50.3; fibre, 13.0; mineral matter, 4.2%; digestible protein, 13.4; total digestible nutrients, 73.8%; and nutritive ratio, 4.5; *seeds*—moisture, 10.0; protein, 23.4; fat, 5.7; N-free extr., 51.5; fibre, 6.4; and mineral matter, 3.0%; digestible protein, 19.0; total digestible nutrients, 81.7%; and nutritive ratio, 3.3. When fed to pigs in excessive quantities, the seeds cause severe vomiting and diarrhoea; the toxic principle is reported to be dihydroxyphenylalanine (Singh, loc. cit.; Morrison, 496–97, 1066; Wehmer, I, 584).

M. monosperma DC.

D.E.P., V, 285; Fl. Br. Ind., II, 185; Talbot, I, Fig. 224.

MAR. *Mothi-kuhili, sonagaravi*; GUJ.—*Adadaveliya, kagadolia*; TEL.—*Enugadulagondi, peddadulagondi*; TAM.—*Periyattalargai, thelu-kodi*; KAN.—*Anipeballi*; MAL.—*Malanthelli*; ORIYA—*Sarni, bai donka*.

NEPAL—*Baldhengra*; KHASI—*Mei-siaryntim*.

A large woody, perennial twiner found from

Nepal eastwards to Khasi hills, Deccan Peninsula and Andaman Islands. Leaves trifoliolate: leaflets ovate-oblong or elliptic; flowers in axillary corymbose racemes, purple; pods orbicular, plaited, winged, densely covered with reddish or dark brown, deciduous, irritant bristles; seed solitary in a pod, nearly circular, slightly compressed, dark brown.

The seeds are restorative and are sometimes consumed as a vegetable. They possess expectorant properties and are used in coughs, asthma and affections of the tongue: applied externally, they are said to be sedative. The trichomes of pods are irritant to the skin and may cause dermatitis (Kirt. & Basu, I, 777; Chopra, 1958, 559).

***M. prurita** Hook. syn. *M. pruriens* Baker (Fl. Br. Ind.), non DC. COMMON COWITCH, COWHAGE

D.E.P., V, 286; Fl. Br. Ind., II, 187; Kirt. & Basu, Pl. 317 B.

HINDI—*Kiwach, kaunch, goncha*; BENG.—*Alkushi, bichchoti*; MAR.—*Kavacha, kuhili, kanchkuri*; GUJ.—*Kivanch, kavatch*; TEL.—*Dulagondi, pilliadugu*; TAM.—*Poonaipidukkan, poonaikalei*; KAN.—*Nasukunni, hasagunigida*; MAL.—*Naicorna*; ORIYA—*Kaincho*.

PUNJAB—*Kawanch, gugli*; NEPAL—*Kaochir, kuach*; LEPCHA—*Kajukop-rik*; MUNDARI—*Itika*; SANTAL—*Etka*.

A herbaceous twining annual found almost all over India and in Andaman and Nicobar Islands. Leaves trifoliolate: leaflets broadly ovate, elliptic or rhomboid ovate, unequal at base; flowers in axillary, pendulous racemes, purple; pods curved, 5–10 cm. × 1.5–1.8 cm., longitudinally ribbed, turgid, densely clothed with persistent pale brown or grey, irritant bristles; seeds black, 4–6 in a pod, ovoid (*c.* 12 mm. long), with funicular hilum.

The plant is found in bushes and hedges, damp places, ravines and scrub jungles throughout the plains of India. It is reported to be a pest of sal plantations in Bengal. The plant is occasionally cultivated. It is hardy, grows vigorously and forms a thick soil covering, smothering the growth of weeds. It is useful as a green manure and cover crop; it is also grown for its pods and young leaves, which are used as vegetable and as fodder. For use as fodder, the crop must be cut when in flower (Use of Leguminous Plants, 228–29; Bor, 95; Datta & Gossip, *Agric. Live-Stk India*, 1931, **1**, 266).

* This species is considered by some authors to be synonymous with *M. pruriens* (Linn.) DC., which is widespread in the tropics.

Analysis of seeds gave the following values: moisture, 9.1; protein, 25.03; ether extr., 2.96; fibre, 6.75; and mineral matter, 3.95%: calcium, 0.16; phosphorus, 0.47; and iron, 0.02%; sulphur and manganese are present. The seeds contain *l*-3:4-dihydroxyphenylalanine or dopa (*c.* 1.5%); glutathione, lecithin, gallic acid and a glucoside are present. They contain also a number of alkaloids (total alkaloids, 0.53%) including nicotine, prurieninine ($C_8H_{16}O_2N_2$, m.p. 213–14° decomp.), prurienidine ($C_6H_{15}O_3N_3$, m.p. 287–88° decomp.), and five other bases designated base P ($C_{17}H_{26}O_6N$, b.p. 118–19°), base Q (b.p. 220–21°), base R ($C_{23}H_{35}O_4N$, b.p. 320°), base S (b.p. above 320°) and base X ($C_{11}H_{25}O_3N$, m.p. 94–95°). When tested on frogs, prurieninine slows down the heart, dilates the blood vessels, depresses blood pressure and increases the peristaltic action of intestines. Prurienidine has also similar effect on blood vessels but has no action on heart (Sarkar, *Ann. Biochem.*, 1945, **5**, 39; Damodaran & Ramaswamy, *Biochem. J.*, 1937, **31**, 2149; Pillai, *Rep. Dep. Res., Univ. Travancore*, 1939–46, 162; Rakhit & Majumdar, *Indian J. Pharm.*, 1956, **18**, 285; Majumdar & Zalani, ibid., 1953, **15**, 62; Majumdar & Paul, *Indian Pharm.*, 1954, **10**, 79).

The pods of *M. prurita* are reported to be used as famine food after repeated boiling and throwing away the water. The biological value of the seed proteins (by the balance sheet method) is 61% at 5% level of protein intake and 55% at 10% protein intake; at 15% level, there was considerable disturbance in the system of experimental rats and as a result there was little growth (Sarkar, loc. cit.).

The seed kernels yield 5.9% of a deep brown, viscous fatty oil with the following characteristics: sp. gr., 0.907; *n*, 1.472; acid val., 22.37; sap. val., 150.1; iod. val., 95.4; acet. val., 110.0; R.M. val., 0.6; Polenske val., 0.4; and unsapon. matter, 10.5%. The fatty acid composition of the oil is as follows: saturated (stearic and palmitic), 22.4; and unsaturated (oleic and linoleic), 76.7%; the unsaponifiable matter contains β-sitosterol. Defatted kernels contain 10% lecithin [Nair & Pillai, *Bull. Res. Inst., Univ. Travancore*, 1954, **3A**(1), 83; Pillai & Anantaraman, ibid., 1955, **4A**(1), 41].

Common Cowitch has long been valued in medicine. The roots are tonic, stimulant, diuretic, purgative and emmenagogue. They are used for diseases of the nervous system, kidney troubles and dropsy. An ointment prepared from the roots is applied for elephantiasis. The seeds are astringent and tonic;

they possess slight insecticidal activity. The leaves of the plant are applied to ulcers (Kirt. & Basu, I, 779; Dastur, Medicinal Plants, 164; Heal *et al., Lloydia,* 1950, **13,** 126).

The bristly hairs covering fresh and dry pods cause intense itching on contact with skin and sometimes cause blisters and dermatitis; a wash with warm water containing alkali or ammonia reduces the burning sensation. The hairs were formerly used as vermifuge and were official in some pharmacopoeias. They are available in bazaars as yellowish brown loosely felted masses, occasionally containing portions of the black pericarp, and administered as a bolus (with fat) or electuary (with treacle, syrup or honey), followed by a purgative. Extracts and infusions of the drug are ineffective. An infusion of hair is used in diseases of the liver and gall bladder and applied externally as a local stimulant and mild vesicant [Santapau, *Rec. bot. Surv. India,* 1953, **16**(1), 74; Chopra, 1958, 605; Quisumbing, 416; Kirt. & Basu, I, 779; U.S.D., 1955, 1758; I.P.C., 150; Bentley & Trimen, II, 78; Wallis, 27; Modi, 577; Steinmetz, I, 174].

The itching caused by the trichomes of the pod is attributed to the presence of a histamine-liberating principle. It is a proteinase, mucunain, which causes local itching, the effect persisting for 3–5 min. Hairs contain 0.015% of serotonin (5-hydroxy tryptamine), which is more active than histamine as a cutaneous pain producer, but has no pruritogenic properties (*Chem. Abstr.,* 1954, **48,** 883; Shelley & Arthur, *Science,* 1955, **122,** 469; Bowden *et al., Nature, Lond.,* 1954, **174,** 925).

M. atropurpurea DC.; Baker (Fl. Br. Ind.) in part (Tel.—*Gededula gondi, pedda dulagondi, tillakada;* Tam.—*Talargodi;* Dehra Dun—*Bhainswalibel*) is a woody twiner with purple flowers and bristly, 2-seeded pods found in the outer Himalayas from Jaunsar to Kumaon and in the Deccan Peninsula up to an altitude of 900 m. The bristles on pods are irritant and cause dermatitis (Chopra, 1958, 559).

M. bracteata DC. (Garo—*Wakmi*) is an annual or perennial twiner found in tropical eastern Himalayas and Assam. The seeds and trichomes from pods are reported to possess medicinal properties similar to those of *M. prurita* (Fl. Assam, II, 68).

M. capitata Wight & Arn. is a twiner found in the foot-hills of the Himalayas and Central India. The seeds are considered tonic. They contain protein (27%), fatty oil (2%), an alkaloid and dihydroxyphenylalanine (>3%). The toxic principle may be eliminated from the seeds by maceration with dil. hydrochloric acid followed by washing with water; the treated material may be used as feed for animals. The fatty oil (sp. gr., 0.865; acid val., 6.7; sap. val., 178.2; iod. val., 104.0; and R.M. val., 0.77) contains palmitic, stearic and oleic acids [Roi, 376; Wehmer, I, 584; *Chem. Abstr.,* 1958, **52,** 4062; Nair & Pillai, *Bull. Res. Inst., Univ. Travancore,* 1954, **3A**(1), 83].

M. gigantea DC. (Elephant Cowitch; Tel.—*Enugadulagondi;* Tam.—*Kalgaivalli;* Kan.—*Turibilangi;* Mal.—*Kakavalli*) is an extensive, littoral twiner with yellow, pale green or whitish flowers and broadly winged pods found in the tidal forests of India and in the Andaman Islands. The bark is used in external applications for rheumatic complaints. Powdered seeds are said to be used as a purgative in Hawaii. The hairs on pods produce intense irritation and dermatitis. This species is suspected to be poisonous to pigs in Australia (Kirt. & Basu, I, 778; Burkill, II, 1503; Neal, 404; Chopra, 1958, 559; Webb, *Bull. Coun. sci. industr. Res. Aust.,* No. 232, 1948, 91).

M. hirsuta Wight & Arn. is an annual twiner bearing purple flowers and curved pods covered with silvery brown bristles found at lower elevations on western ghats and Nilgiri and Palni hills. The bristles on pods cause dermatitis (Chopra, 1958, 559).

M. macrocarpa Wall. (Nepal—*Baldhengra;* Lepcha—*Tanyerik;* Khasi—*Meijendru, jermi-jendru, thar-jendru*) is a large woody twiner found in Nepal, eastern Himalayas and Assam, ascending to an altitude of 2,000 m. It is reported to damage saplings in forests and is kept under check by periodical cutting (Gamble, 240; Troup, I, 250).

M. nigricans Steud. syn. *M. imbricata* DC. (Beng.—*Kasi;* Nepal—*Kaoso;* Lepcha—*Dangyimrik;* Mundari—*Marang-itika;* Assam—*Mekuri-ghila*) is a large woody twiner with dull purple flowers and oblong pods clothed with yellowish brown irritating bristles found in the sub-Himalayan tract, Bihar, North Bengal, Assam, southern parts of Madhya Pradesh and Andaman Islands. The watery sap from the stem is used in Philippines for coughs and fevers. The hairs on pods produce dermatitis (Fox, *Philipp. J. Sci.,* 1952, **81,** 323; Brown, 1941, II, 134; Chopra *et al.,* 40).

M. utilis Wall. ex Wight, a species known only under cultivation in India, resembles *M. prurita* and

M. deeringiana to some extent; it has been considered by many authors to be a variety of either of these species. It bears purple flowers and velvety pods 8–12 cm. long; the seeds are dull black, faintly marked with brown flecks. Analysis of seeds, which are much larger than those of *M. prurita*, gave the following values: moisture, 12.0; protein, 27.8; ether extr., 4.5; and ash, 3.3%. The seed proteins have practically no growth promoting value; the biological value is also low, 43% at 10.5% level of protein intake and 56% at 6.25% intake level; the corresponding digestibility values are 82.4% and 81.9%. The seeds are more toxic than those of *M. prurita* (Sarkar & Bose, *Ann. Biochem.*, 1945, **5**, 55).

MUHLENBERGIA Schreb. (*Gramineae*)

D.E.P., III, 436; Fl. Br. Ind., VII, 258.

A genus of annual or perennial grasses, mostly American. Three species have been recorded in India. *M. huegelii* Trin. syn. *M. viridissima* Nees ex Steud. is a slender grass with stems up to 30–90 cm. and smooth or scaberulous leaves found in temperate Himalayas from Kashmir to Sikkim at 900–2,700 m. and in Khasi hills. The grass is considered useful as fodder. Analysis of the grass (from Indonesia) gave the following values (dry basis): protein, 12.8; fat, 2.46; carbohydrates, 44.8; fibre, 29.7; and ash, 10.1% (Walandouw, *J. sci. Res. Indonesia*, 1952, **1**, 201).

Mukia — *see* **Melothria**

Mulberry — *see* **Morus**

Mulberry, Paper — *see* **Broussonetia**

Mule Fern — *see* **Hemionitis**

Mules — *see* **Livestock**

Mullein — *see* **Verbascum**

Mullein Pink — *see* **Lychnis**

Mullite — *see* **Kyanite; Sillimanite**

MUNDULEA Benth. (*Leguminosae*)

A small genus of shrubs or small trees found in Africa, Madagascar, India and Ceylon. One species occurs in India.

M. sericea Cheval. syn. *M. suberosa* Benth.

D.E.P., V, 288; C.P., 546; Fl. Br. Ind., II, 110; Kirt. & Basu, Pl. 301.

TEL.—*Kondavempali, palasaram, verri billudu*;

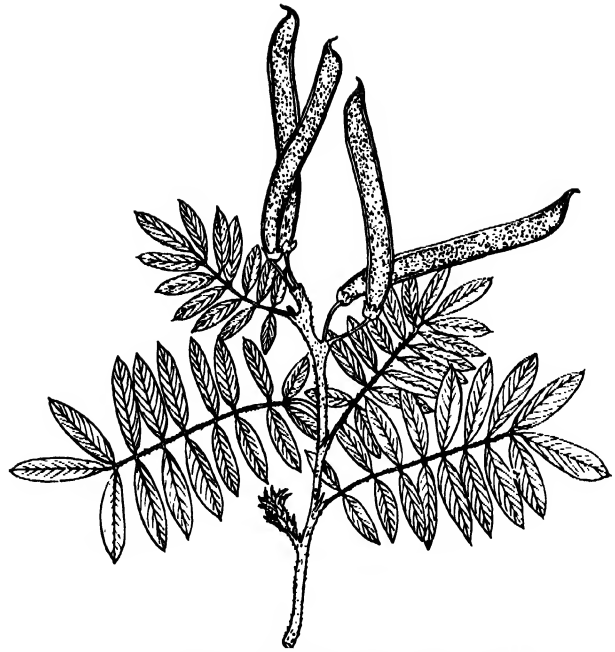


FIG. 172. MUNDULEA SERICEA—FRUITING BRANCH

TAM.—*Pilavaram, vellaipporasu*; KAN.—*Bettahuruli, kadutuvari*; MAL.—*Kattutuvara.*

DECCAN—*Supti, suri.*

A stout erect shrub or small tree, 3.0–4.5 m. high, found in dry forests and rocky hills of west and south India, in Konkan, Circars, Deccan and Carnatic to Tinnevelly, up to an altitude of 1,200 m. Bark thick, corky, yellow; leaves imparipinnate: leaflets oblong-lanceolate; flowers pinkish violet or reddish, in close terminal racemes; pods linear, flattened, densely velvety with short golden brown hairs; seeds 3–8, yellowish brown.

The plant can be propagated by seeds. It coppices freely and is regarded as a useful plant for reafforesting bare hills. When found growing in evergreen bush or forest regions, the plant has a smooth non-corky bark (Greenway, *Kew Bull.*, 1936, 245; Bourdillon, 116; Holman, 92).

M. sericea possesses insecticidal and piscicidal properties. All parts of the plant, particularly the bark and seeds, are toxic. Dry conditions and calcareous soils are favourable for the formation of toxic principles; attempts have been made to isolate strains with high insecticidal potency by selection. Ground bark, especially preparations from smooth non-corky bark, is a powerful insecticide, of the same order of potency as derris root, and has been successfully used against a number of insect pests. Used as dust, it is toxic to caterpillars, cockroaches, pulse beetles

and house flies. In India, the whole plant has been tried in the form of dust, against cattle lice and fleas, *Epilachna* beetle grub and mosquito larvae, and found effective. Aqueous extracts of the plant are effective against aphids, grasshoppers and mango-hopper nymphs (*Idiocerus* sp.). The bark is reported to be used in E. Africa to drive away crocodiles from rivers. The activity of the bark is not much affected by storage in closed containers in a dry condition, but extracts lose their activity on keeping in contact with solvents [Greenway, loc. cit.; Holman, 91–92; Spickett, *Colon. Pl. Anim. Prod.*, 1955, **5**, 288; Spoon & Loosjes, *Tijdschr. PlZiekt.*, 1959, **65**(3), 79; Puttarudriah, *Mysore agric. J.*, 1954, **30**, 70; *Chem. Abstr.*, 1936, **30**, 4986; Subramanian, *J. Mysore agric. exp. Un.*, 1932, **13**, 58; Chopra *et al.*, 395; *Adm. Rep., Dep. Agric. Mysore*, 1933–34, 12].

The bark of *M. sericea* from E. Africa contains rotenone (the chief toxic constituent of derris root). The toxicity of the bark, however, cannot be accounted for on the basis of rotenone alone. Analysis of several samples revealed that while the rotenone content varied from 0 to 1.1%, extracts of bark from some areas were as toxic as that of derris containing 5.4% rotenone. A crystalline substance, $C_{23}H_{20}O_7$ (m.p. 193°), possessing a toxicity towards fish approaching that of rotenone, has been isolated from the stem bark. The same substance has been isolated from the root bark, along with a yellow compound (m.p. 216°) of the same empirical formula (Spickett, loc. cit.; Holman, 92).

Extracts of the leaf, bark, stem and root of *M. sericea* plants growing in India did not give a positive Durham test and attempts to isolate rotenone from them were unsuccessful. A substance designated munetone [2-methoxy-7:8-(2-*iso*propyl-4:5-furano)-*iso*flavone, $C_{21}H_{18}O_4$, m.p. 192–93°, yield 0.3%] and 2 minor compounds, $C_{20}H_{18}O_6$ (m.p. 216–17°) and $C_{15}H_{28}O$ (m.p. 74–75°), have been isolated from the root bark. Munetone is highly toxic to fish and is possibly an intermediate in the biosynthesis of rotenone-type compounds. The seeds contain a crystalline principle, mundulea substance A ($C_{25}H_{24}O_6$, m.p. 180–82°, yield 0.15%), which is as toxic to fish as rotenone. In addition, they contain a second crystalline substance (m.p. 187–89°) and amorphous fractions possessing considerable toxicity towards fish. Mundulea substance A and toxic amorphous fractions occur also in roots. Leaves contain *iso*rhamnetin and a crystalline substance, $C_{16}H_{20}O_6N$ (m.p. 199°) (Spickett, loc. cit.; Dutta, *J. Indian chem. Soc.*, 1956, **33**, 716; 1959, **36**, 165; Narayana & Rangaswami, *J. sci. industr. Res.*, 1955, **14B**, 105; *Indian J. Pharm.*, 1954, **16**, 171).

Ethanol extracts of fruits and leaves of *M. sericea* are active against Gram-positive bacteria and *Mycobacterium tuberculosis*. The bark contains a toxic glycoside; a non-alkaloidal thermostable principle with a marked depressor action, due chiefly to its effect on the myocardium is also present (Nickell, *Econ. Bot.*, 1959, **13**, 281; *Chem. Abstr.*, 1946, **40**, 7394).

MUNTINGIA Linn. (*Tiliaceae*)

Benthall, 66.

A monotypic genus, comprising *Muntingia calabura* Linn. (JAPANESE CHERRY), native of South America, cultivated all over the tropics for ornament and for its edible fruit.

M. calabura is a small or medium-sized tree with spreading branches; leaves obliquely lanceolate, serrate; flowers small, white, borne on stalks c. 2.5 cm. long; fruit a berry, smooth, red, globose or obovid, c. 1.5 cm. diam., containing many seeds embedded in a juicy pulp.

FIG. 173. MUNTINGIA CALABURA—FLOWERING AND FRUITING BRANCH

The plant can be propagated by cuttings of half-ripe shoots in sandy places. It grows rapidly and its evergreen foliage, combined with dwarf habit, makes it an excellent ornamental tree for lawns. The fruits are sweet and pleasant to taste and can be made into jams and tarts. The edible pulp including seeds contain: total solids, 24.6; insol. solids, 8.4; protein, 1.98; reducing sugars, 8.05; sucrose, 5.34; acids (as malic), 0.08; and ash, 0.80% (Chittenden, III, 1326; Gopalaswamiengar, 245; Benthall, 67; Burkill, II, 1504; Winton & Winton, II, 770).

The heartwood of the tree is light, fairly lustrous and firm. It is easily worked, but is not durable; it is of no commercial value. Infusion of the leaves is used as tea, that of flowers for headaches and incipient colds. The tough fibre of the bark is used for ropes and cordage (Burkill, II, 1504; Record & Hess, 146; Benthall, 67; Brown, 1941, II, 394; Neal, 479).

MURRAYA Linn. (*Rutaceae*)

A genus of shrubs or small trees distributed from South and East Asia to Australia. Two species occur in India.

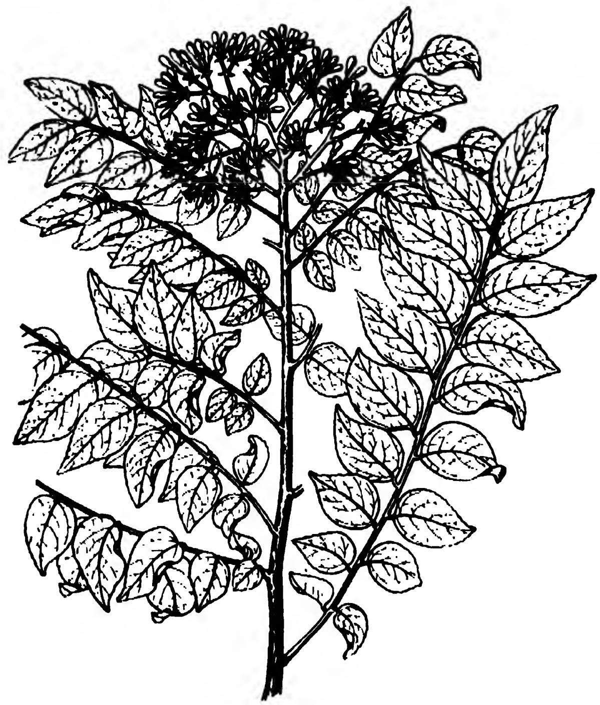


FIG. 174. MURRAYA KOENIGII—FLOWERING BRANCH

M. koenigii (Linn.) Spreng. CURRY LEAF TREE

D.E.P., V, 288; Fl. Br. Ind., I, 503; Swingle in Webber & Batchelor, I, 200.

HINDI—*Kathnim, mitha neem, kurry patta, gandhela, barsanga*; BENG.—*Barsanga, kariaphulli*; MAR.—*Karhinimb, poospala, gandla, jhirang*; GUJ.—*Goranimb, kadhilimbdo*; TEL.—*Karepaku*; TAM.—*Karivempu, karuveppilei, kattuveppilei*; KAN.—*Karibevu*; MAL.—*Kariveppilei*; ORIYA—*Barsan, basango, bhursunga*.

ASSAM—*Narasingha, bishahari*.

A handsome, aromatic, more or less deciduous shrub or a small tree, up to 6 m. in height and 15–40 cm. in diam., found almost throughout India and the Andaman Islands up to an altitude of 1,500 m. Bark dark brown or almost black; leaves imparipinnate: leaflets 9–25, ovate, lanceolate or somewhat rhomboid, irregularly crenate-dentate, acuminate, obtuse or acute, base usually oblique, almost glabrous above, pubescent beneath, gland-dotted, strongly aromatic; flowers in terminal corymbose cymes, white, fragrant; berries sub-globose or ellipsoid, purplish black when ripe, 2-seeded.

M. koenigii is commonly found in forests, often as gregarious under-growth. It is much cultivated for its aromatic leaves and for ornament throughout India. Propagation is by seeds, which germinate freely under partial shade; a spacing of 15–20 ft. has been suggested for planting seedlings. The plant is subject to white sap rot caused by *Fomes pectinatus* Klotszch; a collar rot of seedlings, caused by *Rhizoctonia* (*Corticium*) *solani* Kuhn, has been reported from Nagpur [Cameron, 48; *Indian J. agric. Sci.*, 1950, **20**, 107; Jain & Mahmud, *Nagpur agric. Coll. Mag.*, 1951-52, **26**(1–4), 18].

The leaves of the plant are extensively employed as flavouring in curries and chutneys. Analysis of leaves gave the following values: moisture, 66.3; protein, 6.1; fat (ether extr.), 1.0; carbohydrate, 16.0; fibre, 6.4; and mineral matter, 4.2%; calcium, 810 mg.; phosphorus, 600 mg.; and iron, 3.1 mg.; carotene (as vitamin A), 12,600 i.u.; nicotinic acid, 2.3 mg.; and vitamin C, 4 mg./100 g.; thiamine and riboflavin, absent. The leaves are a fair source of vitamin A; they are also a rich source of calcium, but due to the presence of oxalic acid in high concentration (total oxalates, 1.35%; sol. oxalates, 1.15%), its nutritional availability is affected. The free amino acids present in the leaves are: asparagine, glycine, serine, aspartic acid, glutamic acid, theonine, alanine, proline, tyrosine, tryptophan, γ-aminobutyric acid,

phenylalanine, leucine, isoleucine, and traces of ornithine, lysine, arginine and histidine. The leaves also contain a crystalline glucoside, koenigin, and a resin. Twigs and leaves contain 0.8% potash (dry matter basis) (*Hlth Bull.*, No. 23, 1951, 32 ; Anantha Samy *et al.*, *Curr. Sci.*, 1960, **29,** 133 ; Radhakrishnan *et al.*, *J. Indian Inst. Sci.*, 1955, **37A,** 178 ; Mata Prasad & Dange, *Indian For. Leafl.*, No. 95, 1947, 8).

Fresh leaves on steam-distillation under pressure (90 lb./sq. in.) yield 2.6% of a volatile oil (Curry Leaf Oil) which may find use as a fixative for heavy type of soap perfume ; distillation at ordinary pressure gives very poor yields of oil, while distillation with superheated steam (temp., 220°) yields a dark coloured, foul smelling oil. Rectified curry leaf oil is deep yellow in colour with a strong spicy odour and pungent clove-like taste ; it has the following characteristics: sp. gr.$^{25°}$, 0.9748 ; $n^{25°}$, 1.5021 ; $[\alpha]^{25°}$, +4.8° ; sap. val., 5.2 ; sap. val. after acetylation, 54.6 ; acid val., 3.8 ; sol. in 80% alcohol with slight opalescence The oil contains: *dl-α*-phellandrene, 4.6 ; *d*-sabinene, 9.2 ; *d-α*-pinene, 5.5 ; dipentene, 6.8 ; *d-α*-terpineol, 3.2 ; caryophyllene, 26.3 ; isosafrol, 4.4 ; cadinene, 18.2 ; cadinol, 12.8 ; lauric acid, 2.7 ; and palmitic acid, 3.4% (Dutt, *Indian Soap J.*, 1957 58, **23,** 201).

The fruit is edible. It yields 0.76% of a yellow volatile oil with neroli-like odour and pepper-like taste, accompanied by an agreeable sensation of coolness on the tongue. The characteristics of the oil are as follows: sp. gr.$^{13°}$, 0.872 ; n_D, 1.487 ; $[\alpha]_D$, −27.24° ; b.p. 173–74°. The fruit is reported to contain koenigin [Swingle in Webber & Batchelor, I, 202 ; Krishna & Badhwar, *J. sci. industr. Res.*, 1948, **7**(6), suppl., 104 ; Wehmer, I, 621].

The leaves, root and bark are considered tonic, stomachic and carminative. Leaves are used internally in dysentery and diarrhoea, and also for checking vomiting ; they are applied externally to bruises and eruptions. Aqueous extracts of leaves, when administered parenterally to female guinea pigs, not only raise the phagocytic index but also mobilize a greater number of leucocytes to take part in phagocytosis ; the effect does not last long. The juice of the root is taken to relieve pain associated with kidney (Kirt. & Basu, I, 473 ; Broker *et al.*, *Curr. Sci.*, 1953, **22,** 44).

The wood (wt., 43–50 lb./cu.ft.) is greyish white, hard, even- and close-grained and durable. It is used for agricultural implements (Gupta, 93 ; Talbot, I, 194).

M. paniculata (Linn.) Jack syn. *M. exotica* Linn. ORANGE JESSAMINE

D.E.P., V, 288 ; Fl. Br. Ind., I, 502 ; Swingle in Webber & Batchelor, I, 194, Fig. 29.

HINDI—*Kamini, marchula* ; BENG. *Kamini* ; MAR.—*Pandari, kunti, marchulajuti* ; TEL. *Nagagolunga, karepaku* ; TAM. *Konji* ; KAN.—*Angarakana gida, pandry* ; ORIYA—*Ban mallika, harkankali.*

A handsome evergreen shrub or a small tree with spreading crown and short, often crooked, trunk found almost throughout India and the Andaman Islands up to an altitude of 1,500 m. Bark pale yellowish brown, rather corky, fragrant ; leaves imparipinnate ; leaflets 3–9, ovate or elliptic-lanceolate or rhomboid, gland-dotted ; flowers in corymbose cymes, white, fragrant ; berries oblong or ovoid, red or deep orange when ripe, 1–2 seeded.

The plant is commonly grown in gardens for its glossy green foliage and large clusters of fragrant flowers. It is a popular hedge plant and is well

FIG. 175. MURRAYA PANICULATA—FLOWERING BRANCH

adapted for topiary work. Propagation may be done by seeds, cuttings or layering. The plant is subject to the attack of the citrus stem borer, *Chelidonium cinctum* Guer. Removal of infected branches or treatment of affected parts with chloroform and creosote mixture is recommended as control measure (Troup, I, 166; Gopalaswamiengar, 280, 582).

The wood of *M. paniculata* is sometimes referred to as Chinese boxwood or Andaman satinwood in the trade. It is light yellow and lustrous when first exposed, fading to greyish yellow with age, without distinct heartwood; straight- or curly-grained in the radial plane, even- and fine-textured, strong, hard, and heavy (sp. gr., c. 0.83; wt., 53 lb./cu. ft.). It is very refractory to seasoning; slow seasoning in a cool place protected from hot dry winds is recommended; the timber may be felled and converted soon after the monsoon to allow the maximum possible period for seasoning before the onset of hot and dry winds. The wood is durable under cover and requires no treatment. It is moderately easy to saw and works to a smooth surface (Pearson & Brown, I, 199).

The wood is used for tool handles, turnery, cabinet work and walking sticks. It is suitable for mathematical instruments, penholders, brushes, mallet heads, etc. The wood of the root is often beautifully figured and prized for kris handles (Pearson & Brown, I, 199; Howard, 531; Burkill, II, 1506).

The leaves are stimulant and astringent; they are reported to be used for diarrhoea and dysentery in the Philippines. Powdered leaves are applied to cuts. Leaves and root bark are sometimes used against rheumatism, coughs and hysteria. Twigs are used for cleansing teeth. The leaves possess antibiotic activity against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli* (Kirt. & Basu, I, 475; Burkill, II, 1506; van Steenis-Kruseman, *Bull. Org. sci. Res. Indonesia*, No. 18, 1953, 43; Joshi & Magar, *J. sci. industr. Res.*, 1952, **11B**, 261).

Fresh leaves of *M. paniculata* (from Dehra Dun) on steam-distillation yield (0.01%) a dark coloured volatile oil with a pleasant odour. The characteristics of the oil are as follows: $d^{15°}$, 0.9023; $n_D^{22°}$, 1.496; sap. val., 8.87; sap. val. after acetylation, 72.53; not soluble in 10 vol. of 80% alcohol. The oil contains sesquiterpenes (predominantly *l*-cadinene), a sesquiterpene alcohol and probably methyl anthranilate. Flowers are reported to be used in Java for making cosmetics. They contain indole and a bitter crystalline glucoside, murrayin (yield, 1.3%), which is identical with scopolin (7-glucosido-6-methoxycoumarin, $C_{16}H_{18}O_9$, m.p. 218°) [Gildemeister & Hoffmann, 1956, V, 454; Krishna & Badhwar, *J. sci. industr. Res.*, 1948, **7**(6), suppl., 105; Bose & Mookerjee, *J. Indian chem. Soc.*, 1937, **14**, 489].

MUSA Linn. (*Musaceae*)

A genus of perennial tree-like herbs, widely distributed in moist tropics, from Africa in the west to the Polynesian Islands in the east. About 14 species have been recorded in India; 3 or 4 exotic species are cultivated for ornament.

The classification and taxonomy of the genus is rather confused. Earlier classifications were based mainly on morphological characters and on the edibility or inedibility of fruits, but these criteria have proved unacceptable in the light of recent cytogenetical and phytogeographical studies. According to some authors, the single-stemmed monocarpic types with swollen pseudostem bases and a basic chromosome number n=9 should be regarded as belonging to a separate genus, *Ensete* Bruce, the genus *Musa* Linn. being reserved for the true stooling, cylindrical stemmed types with a basic chromosome number n=10 or 11. According to others, the two groups are so closely related that they should be classed together as one genus and individual groups considered as sub-genera. On this basis, the monocarpic types are classified under the sub-genus *Physocaulis* Baker and the true stooling types under the sub-genus *Musa*. From the commercial point of view, *Physocaulis* (*Ensete*) species are not as important as *Musa* spp. (Cheesman, *Kew Bull.*, 1947, 97, 106; Simmonds, 3; Moore, *Baileya*, 1957, **5**, 167; Fl. Egypt, III, 530, 545; Chakravorti, *Indian J. Genet.*, 1951, **11**, 34; Mansfeld, 575).

On the basis of chromosome number and certain morphological features, the sub-genus *Musa* has been divided into four sections, viz. (i) *Musa* (*Eumusa*)* (n=11) having dull coloured bracts enclosing many flowers in two series and distributed from India to Japan and Samoa; (ii) *Rhodochlamys* (Baker) Cheesman (n=11) with bright red coloured bracts and a few flowers, usually in a single series, distributed from India to Indo-China; (iii) *Australimusa* Cheesman (n=10) with sub-globose or dorsiventrally compressed seeds, found from Queensland through North Guinea to Philippine Islands; and (iv) *Callimusa* Cheesman (n=10) with cylindrical,

* For the sake of clarity, the term *Eumusa* is included in the text, though according to Art. 22 of the *Intern. Code bot. Nomencl.*, 1956, the correct term is section *Musa*.

barrel-shaped or top-shaped seeds, distributed in Indonesia and Indo-China. Most of the cultivated or commercially important bananas, particularly those occurring in India, belong to the section *Musa* (*Eumusa*); *Australimusa* includes *M. textilis* (Manila Hemp) and Fehi or Fe'i bananas of the Pacific; *Rhodochlamys* and *Callimusa* include species which are mainly ornamental (Cheesman, *Kew Bull.*, 1947, 106; Simmonds, ibid., 1960, 198; Simmonds, 3).

Section *Musa* (*Eumusa*), the biggest and geographically the most widespread, includes the majority of edible bananas, mostly of hybrid origin. The wild progenitors of edible bananas have been traced to two variable species, viz. *M. acuminata* and *M. balbisiana*, both of which are represented in India. The latter includes mainly diploid seeded types, while *M. acuminata* includes both diploid and triploid forms; hybridization between the two latter types and with types of *M. balbisiana* has resulted in diploid, triploid and tetraploid cultivated forms. The centre of origin of this banana complex is mainly east Asia, comprising Assam, Burma, Malaya, Siam and Indo-China, with perhaps Malaya as the primary centre and India as the secondary one. The sub-genus *Physocaulis* is considered to have originated in South-East Asia, although many of the species at present are found distributed in Africa (Simmonds & Shepherd, *J. Linn. Soc., Bot.*, 1949-57, **55**, 302; Venkataramani, *Madras agric. J.*, 1949, **36**, 552; Chakravorti, loc. cit.; Krishnamurthi & Seshadri, *Indian J. Hort.*, 1958, **15**, 135; Simmonds, 308).

Of the various species and sub-species of *Musa*, only the cultivated edible bananas are of economic importance; others are of intrinsic value, mainly in understanding the evolution of cultivated types and for breeding and selecting desired types to meet the particular needs of a region. In the present account, only the edible bananas of India and the fibre-yielding *M. textilis* are dealt with. Other species are enumerated in Table 1 and their characteristics and economic importance are briefly indicated.

The evolution of edible bananas is closely associated with four factors, viz. parthenocarpy, sterility, vegetative propagation and polyploidy. Edibility depends primarily on the occurrence of parthenocarpy or development of a mass of pulp from the ovary without fertilization. Pulp development starts from the inner face of the skin and is supplemented by swelling of septa and axis. Parthenocarpy is often accompanied by female sterility and consequent seedlessness. Parthenocarpy and sterility have arisen probably due to gene-mutations in fertile diploids, which became established by human selection and vegetative propagation. The occurrence of polyploidy, particularly of triploids, contributes to increased vigour and the large size of fruits. Continued vegetative propagation has resulted in the accumulation of structural changes in the chromosome mechanism, thus making sterility more complete (Simmonds, 29; Chakravorti, loc. cit.; Krishnamurthi & Seshadri, loc. cit.).

M. acuminata Colla syn. *M. cavendishii* Lamb. ex Paxt.; *M. chinensis* Sweet; *M. banksii* F. Muell. (including var. *singampatti* Nayar); *M. nana* Lour. (?); *M. zebrina* Van Houtte ex Planch.; *M. chiliocarpa* Backer ex Heyne

Cheesman, *Kew Bull.*, 1948, 17; Simmonds, ibid., 1956, 463; Moore, *Baileya*, 1957, **5**, 176.

A freely or sparsely stooling plant with pseudostem 3–7 m. high, usually heavily blotched with brown or black; leaf sheaths and petioles often covered with bloom; leaf blades 2.0-2.5 m. long × 40–60 cm. wide, oblong, truncate at apex, varying from green to purple; inflorescence horizontal or pendent with pubescent rachis and peduncle; fruit bunches compact or asymmetrical with sub-cylindrical, shortly pedicelled and prominently beaked fingers, 8-13 cm. long × 1.5–3.0 cm. diam.; seeds when present dull black, smooth or tubercular, embedded in whitish or creamy to yellow pulp.

M. acuminata has a fairly wide distribution and occurs in Assam, Burma, Ceylon, Indo-China, Siam, Malaysia, Australia, Samoa and Philippine Islands; it has been reported also from parts of Peninsular India. It exhibits great variation and has been split up into 5 sub-species on the basis of cytogenetic and phytogeographical studies. The forms included under the sub-species are interfertile and the whole assemblage forms a panmictic unit (Simmonds & Shepherd, *J. Linn. Soc., Bot.*, 1949–57, **55**, 302; Simmonds, *Kew Bull.*, 1960, 198; Nayar, *Indian J. Hort.*, 1952, **9**, 13; Venkataramani, *J. Indian bot. Soc.*, 1955, **34**, 79; Sundararaj, *S. Indian Hort.*, 1955, **3**, 16).

Both seeded (wild) and seedless (edible) forms of *M. acuminata* occur as normal diploid plants, in addition to triploids. Edible forms are said to have arisen through the evolution of parthenocarpy and sterility in diploid forms; through outcrossing of edible diploids with wild forms of *M. acuminata* and *M. balbisiana*, followed by human selection; and

TABLE 1—CHARACTERISTICS AND DISTRIBUTION OF SOME WILD SPECIES OF MUSA IN INDIA

Specific name	Distribution	Characteristics	Remarks
Sub-genus **MUSA**			
Section *MUSA*			
M. cheesmanii Simmonds[2] (*Kol, kabu*)	Dimapur (Assam) at 750-1,050 m.	Densely stooling; fruits angular, curved, whitish green; seeds large, flattened, sub-globose, rough-warty	Seeds reminiscent of *Musa balbisiana*, but about twice as large
M. flaviflora Simmonds[2] syn. *M. thomsoni* King ex Cowan & Cowan (*Kait dewrit, losoarung, nachang*)	Sikkim(?); Assam, Khasi hills, Mikir & Mariani hills, Haflong, Manipur	Habit similar to *M. acuminata*; bracts orange yellow in male flowers	Resembles *M. acuminata*; natural hybrids with *M. velutina* occur in Assam
M. itinerans Cheesman[2,3]	Manipur	Freely stooling; fruits yellow when ripe; seeds tuberculate	2n = 22; closely allied to *M. baspoo*
M. nagensium Prain[2,3]	Naga hills	Pseudostem slender; fruits pointing forward & downward; seeds large, sub-globose, obscurely warty	2n = 22; seeds resemble those of *Ensete gillettii* Cheesman
M. sikkimensis Kurz[2,5,6] syn. *M. hookeri* King ex Cowan & Cowan (*Bon kera, layai*)	Sikkim, N. Bengal, Khasi hills, Manipur	Robust with pseudostem smudged blackish brown; inflorescence far out-shot from pseudostem; fruits splayed, massive, angular; seeds sharply angular, smooth	Distributed through higher ground between Tibet & Burma; seeds resemble those of *M. nagensium*
Section *RHODOCHLAMYS* (Baker) Cheesman			
M. mannii Wendl. ex Baker[4,6]	Assam	Small-sized with pseudostem tinged with black; fruit greenish, 5 cm. long, with thin pulp & many black seeds	Species not fully studied
M. ornata Roxb.[2-4,8,10] syn. *M. rosacea* auct. non Jacq. (*Ramanigi kula, buring tonang kera*)	Sikkim, N. Bengal, Chota Nagpur, Orissa, Konkan hills	Freely stooling with slender pseudostem; inflorescence erect; fruit bunch compact; fruit 6-8 cm. long, inflexed, green yellow with black, warty, irregularly depressed seeds	2n = 22; ornamental; scape eaten after boiling or dried & made into flour
M. sanguinea Hook. f.[6,7]	Assam	Freely stooling; pseudostem slender; inflorescence horizontal; fruit up to 7 cm. long, greenish yellow; seeds angulate depressed, tuberculate	2n = 22; ornamental
M. velutina Wendl. & Drude[4,7] syn. *M. dasycarpa* Kurz (?)	Assam	Freely stooling; inflorescence erect; fruit bright pink, hairy, c. 7 cm. long; pericarp splitting in irregular mass exposing seeds; seeds irregularly angulate-depressed, tuberculate	2n = 22; hybridizes with *M. flaviflora*[2]
Sub-genus **PHYSOCAULIS** Baker (= **ENSETE** Bruce)			
M. superba Roxb.[4,6,9,11,17-19] = *Ensete superbum* Cheesman	Western ghats from Bombay to Travancore hills & ravine slopes & in Assam	Non-stoloniferous with stout pseudostem 3-3.5 m. high; inflorescence drooping, up to 1.2 m long; fruit pale yellow with thick skin; seeds numerous, blackish, sub-globose, 8-12 mm. in diam.	2n = 18; rootstock & young inflorescence eaten; fruit pickled when young; often cultivated for ornament
M. glauca Roxb. syn. (?) *M. nepalensis* Wall.[4,6,11,16] *Ensete glaucum* (Roxb.) Cheesman	Probably found in Khasi hills & Lower slopes of Himalayas in Nepal	Non-stoloniferous; fruit clavate, with black globose seeds, 12 mm. in diam.	Grown in gardens; seeds used in rosaries
M. agharkarii Chakravorti[1] (*Gada kela*)	Chittagong hills	Non-stoloniferous; fruit small, obovoid, few seeded; seeds large, rounded, 12 mm. in diam.	2n = 18

TABLE 1 –*contd.*

Specific name	Distribution	Characteristics	Remarks
M. ensete J. F. Gmelin[4,11-15] – *Ensete ventricosum* (Welw.) Cheesman syn. *E. edule* Horan.	Native of tropical Africa; cultivated in Assam & other areas	Non-stoloniferous; pseudostem tall, 4–9 m. high; inflorescence 1.0 m. or more in length; fruit oblong or pear shaped with 15–25 seeds; seeds large, 12–17 mm. in diam.	2n 18; yields a fibre used for cordage & textile purposes; seeds used for necklaces; starch obtained from pseudostem & fruit

[1] Chakravorti, *J. Indian bot. Soc.*, 1948, **27**, 90; [2] Simmonds, *Kew Bull.*, 1956, 463; [3] Cheesman, *Kew Bull.*, 1949, 23; [4] Moore, *Baileya*, 1957, **5**, 183; [5] Cheesman, *Kew Bull.*, 1948, 325; [6] Fl. Br. Ind., VI, 262 63; [7] Cheesman, *Kew Bull.*, 1949, 133, 135; [8] D.E.P., V, 290 307; [9] Bressers, 148; [10] Haines, VI, 1126; Mooney, 204; [11] Cheesman, *Kew Bull.*, 1947, 97; [12] Baker & Simmonds, *Kew Bull.*, 1953, 405; [13] Choudhury, *Indian For.*, 1959, **85**, 422; [14] Gopalaswamiengar, 341; [15] Fl. Egypt, III, 532-38; [16] Simmonds, *Trop. Agriculture, Trin.*, 1956, **33**, 251; [17] Fl. Madras, 1497; [18] Santapau, *Rec. bot. Surv. India*, 1953, **16**, 316; [19] Gowder & Nambisan, *Indian Hort*. 1958–59, **3**(2), 8.

through the occurrence of triploidy in *M. acuminata* itself and in crosses between *M. acuminata* and *M. balbisiana*, thus resulting in two genetically distinct types of triploids (Cheesman, *Kew Bull.*, 1947, 106; Simmonds, ibid., 1956, 463; 1960, 198; Simmonds, 308).

Cultivated types of *M. acuminata* have been broadly grouped as dwarf, medium tall and tall on the basis of their habit. Dwarf types were considered by earlier workers as a separate species, *M. cavendishii*. It has now been shown that they are mutations from tall members of the group, chosen because of their low stature which makes them less susceptible to wind damage and their better adaptation to growth in cool climates. Dwarf bananas show intergrading forms connecting dwarf types with more than one tall variety. *Basrai* (*Vamankeli* or *Kabuli*), commonly cultivated in Bombay, Madras and other States, is typical of the edible dwarf type. *Gros Michel*, a well-known clone in West Indies and S. America, is a type belonging to the tall group; it is grown to some extent in Bombay and Madras. Other clones cultivated widely in India are: *Harichal* (*Pedda pacha arati*), *Chakkarakeli*, *Lal kel* (*Chenkadali*, *Sevvazhai*), *Green red* (*Venkadali*), *Chingan*, *Kadali* and *Matti*. The last one is a diploid type confined to the hill ranges of Kanyakumari district in Madras State; it thrives only at elevations of 300 600 m. with an average rainfall of 300 cm. and suffers in grade and quality when grown in plains (Nayar & Bhakthavathsalu, *Indian J. Hort.*, 1955, **12**, 22; Simmonds, *Kew Bull.*, 1956, 463; Gowder & Nambisan, *S. Indian Hort.*, 1959, **7**, 20).

M. balbisiana Colla syn. *M. sapientum* var. *pruinosa* King ex Cowan & Cowan

Cheesman, *Kew Bull.*, 1948, 11; Moore, *Baileya*, 1957, **5**, 177; Jacob, K.C., 127, Fig. 71.

NEPAL—*Boukera*; KHASI—*Kait dewsan*; MANIPUR—*Chungbi anguoba*; ASSAM—*Athiya kol*.

A freely stooling plant with green or yellowish green pseudostem, up to 6 m. high and 30 cm. diam. at the base; leaves oblong, 3 m. long × 60 cm. wide, truncate at apex, green above, paler and more or less glaucous beneath; inflorescence pendulous with glabrous peduncle and rachis; male bud ovoid to

FIG. 176. 'DWARF CAVENDISH' (VAMANKELI)—IN FRUIT

ellipsoid with more than one bract lifting at a time; fruit bunch pendent, compact with pale yellow fruits, 7–15 cm. long and 4 cm. diam., more or less distinctly angulate at maturity: pulp whitish; seeds 5–6 mm. long and 4–5 mm. broad, black, minutely warty, irregularly globose.

M. balbisiana occurs in Assam, Sikkim and S. India, extending northward, eastward and southward to Burma, China, Philippines, New Guinea and Ceylon; it is cultivated, perhaps naturalized, in Thailand, Malaya and Indonesia. It is apparently the least variable among the *Musa* species and is widely distributed. It grows vigorously and is resistant to diseases. It is easy to grow and does not hybridize well with other species. It has been occasionally confused with *M. textilis* in the Philippines, because some of its forms yield a fibre similar to that of *M. textilis*, though inferior in quality.

This species includes mainly diploid ($n=11$) seeded types; edible triploids are not found and such types as are under cultivation are considered to be hybrids with *M. acuminata*. However, some diploid types are useful to a limited extent for food, fibre or other assorted purposes. Buds are eaten and are preferred to buds of other edible bananas as they are less astringent; male flowers and immature fruits are sometimes used in curries. Leaves are preferred for platters and for wrapping, and *Elavazhai*, *Ginjaliarati* or *Kallubale* grown in some parts of S. India for leaves are referred to this species. *Butuhan* and *Pacol* grown in the Philippines for fibre and used as a substitute or adulterant of abaca (*M. textilis*) are also considered to belong to this species (Simmonds, *Kew Bull.*, 1956, 463; Simmonds & Shepherd, *J. Linn. Soc., Bot.*, 1949–57, **55,** 302 Brewbaker *et al.*, *Philipp. Agric.*, 1956–57, **40,** 242 Venkataramani, *Madras agric. J.*, 1949, **36,** 552 Simmonds, 268–69; Jacob, K. C., 128).

***M. × paradisiaca** Linn. syn. *M. × sapientum* Linn. EDIBLE BANANA, PLANTAIN

D.E.P., V, 290; C.P., 786; Fl. Br. Ind., VI, 261; Cheesman, *Kew Bull.*, 1948, 145; Moore, *Baileya*, 1957, **5,** 185.

* The use of the Linnaean names *M. paradisiaca* and *M. sapientum* is considered not consistent with the current knowledge of the specific nature of edible bananas. However, it appears useful to retain the name *M. paradisiaca*, because it is the type species of the genus. Following a recent suggestion, the specific epithet has been prefixed by the sign 'X' to denote its hybrid origin (Simmonds, 53–54; Moore, *Baileya*, 1957, **5,** 171).

SANS.—*Kadali, rambha;* HINDI—*Kela;* TEL.—*Arati, anati;* TAM.—*Vazhai;* KAN.—*Bale;* MAL.—*Vazha.*

Edible bananas of hybrid origin valued for their seedless fruits are included under this specific name. They comprise all the diploid, triploid or tetraploid clones, mainly hybrids of *M. acuminata* and *M. balbisiana.*

In all the earlier classifications, the edible clones have been grouped under the two Linnaean names *M. paradisiaca* and *M. sapientum,* the former including mainly culinary types (plantains) and the latter, the dessert types (bananas). Such a delimitation has been found to be artificial, since some of the so-called plantains are eaten when ripe. Several botanists have, therefore, treated all the types as belonging to a single species and assigned them to *M. paradisiaca* on grounds of priority and reduced *M. sapientum* to a varietal or sub-specific status, while a few others followed the reverse procedure and reduced *M. paradisiaca* as a variety of *M. sapientum.* To overcome this confusion, it was suggested that all edible banana clones should be treated as varieties and forms of a combined putative species *M. sapidisiaca* Jacob. However, the botanical features on which the species are based have been found to be unstable and the specific names themselves have been variously used to designate wild as well as cultivated types. It is suggested, therefore, that the continued use of the two Linnaean names should be avoided and in their place cultivar names, as proposed under the current International Rules of Nomenclature of Cultivated Plants, should be used, based mainly on ploidy and the contribution made by the two wild species *M. acuminata* and *M. balbisiana.* According to this view, cultivated banana types may be classed under six groups, each designated by letters which indicate their ploidy and genomic composition with respect to the two parent species (A for *M. acuminata* and B for *M. balbisiana*); thus, AA and AAA stand for diploid and triploid derivatives of *M. acuminata* and AB, AAB and ABB represent diploid and triploid hybrids, the first two having one and the third two genomes from *M. balbisiana* combined with one, two and one genomes of *M. acuminata* respectively. Somatic mutations have arisen among almost all groups of clones mentioned above and have further augmented diversification. Many of them are cultivated in India and they show variations in habit, fruiting behaviour, colour and quality of fruits (Jacob, K. C., 10–11; Krishnamurthi &

MUSA PARADISIACA — IN FLOWER & FRUIT

Seshadri, *Indian J. Hort.*, 1958, **15**, 135; Simmonds, 53-54; 58).

A larger number of edible clones are cultivated in India than in any other country. The great majority of them belong to the section *Eumusa;* clones belonging to *Australimusa* are practically unrepresented in India, except *M. textilis* (Manila Hemp) which has been experimentally tried in some areas. The edible clones of the *Eumusa* section cultivated in India number about 34; many of them (*c.* 22) are mutants selected and perpetuated for certain agricultural and fruit characteristics, and the specific, varietal and scientific appellations given to many of them require clarification. Some work in this direction has been attempted in Madras, Bombay and Trinidad. The clones grown in India are mostly diploid and triploid cultivars of groups AB, AAB and ABB derived evidently as a result of hybridization between *M. acuminata* types and local *M. balbisiana* types. In addition, some diploid (AA) and triploid (AAA) clones of *M. acuminata* are also grown, some of them considered as introductions from Malaysia. Table 2 summarizes the characteristics of some of the commercial types grown in India and the cultivar groups to which they are assigned (Simmonds, 111-13, 124; Venkataramani, *Proc. Indian Acad. Sci.*, 1946, **23B,** 113; Jacob, K.C., 27-32; Gandhi, *Poona agric. Coll. Mag.*, 1955 56, **46,** 27).

Nendran is the leading commercial type grown in Kerala, while *Virupakshi* or *Sirumalai* is the type cultivated in lower Palnis. In most parts of Madras, West Bengal and Bihar, *Poovan* or *Champa* is popular and in Maharashtra and Gujarat, *Basrai* is extensively cultivated. Some of these types are susceptible to wilt or Panama disease. Very little work has been done in India to evolve types resistant to Panama disease. In Trinidad and a few other centres, attempts have been made to select resistant types with desired combination of characters to replace

FIG. 177. FRUIT BUNCH OF NENDRAN

TABLE 2—CHARACTERISTICS OF SOME COMMERCIAL TYPES OF BANANAS CULTIVATED IN INDIA*

Types or clones	Habit	Leaves	Fruit	Wt. of bunch	Remarks
Cultivar: Sucrier (AA) *Chingan, Matti, Kadali*	Medium sized, with light or yellowish green pseudostem *c.* 2.5 m. high, marked with large dark blotches	Linear oblong, light green or greenish yellow, glaucous	5-ridged, green or straw yellow when ripe, with light cream-coloured juicy & sweet pulp	Up to 40 lb. with 10-15 hands	Fruits not easily dropping off; keeping quality good; found mainly in the West Coast & Kanyakumari District (Madras)
Cultivar: Dwarf Cavendish (AAA) *Basrai, Loton, Kabuli, Vamankeli, Pachavazhai, Pachabale, Kuzhivazhai, Mauritius, Bhusaval*	Dwarf or medium sized; susceptible to bunchy top and leaf spot, immune to Panama disease	Close set, broad	Large, curved, dull yellow or greenish yellow with dull white, fairly sweet, soft pulp	45-60 lb. with *c.* 130 fruits	Keeping quality not particularly good; commercially important in Bombay & Madras
Cultivar: Giant Cavendish (AAA) *Harichal, Bombay green, Pedda pacha arati, Bongali jahaji*	Semi-tall, 2.4-3.6 m. high	Large, 1.8 m. long × 60 cm. broad	Long & big, tapering to apex, green when ripe, with cream coloured delicious pulp of spicy flavour	*c.* 60 lb. with 160 fruits	Keeps better than the previous group; grown in dry districts of Bombay, Madras & Andhra Pradesh
Cultivar: Red & Green Red (AAA) *Chenkadali, Lalkel, Venkadali, Sevvazhai, Anupan*	Robust, tall, *c.* 4.5 m. high, moderately stooling, with dark reddish violet pseudostem	Dark green, 2 long × 85 cm. wide	Large, stout, curved, slightly angular when young with blunt apex; pulp pale yellow, firm, fairly sweet, attractive flavour	40-50 lb. with 7-10 hands	Fairly good dessert quality; grown in Kerala, Madras & Bombay
Cultivar: Mysore (AAB) *Poovan, Lal velchi, Champa, Karpura chakkarakeli*	Moderately stooling, tall, *c.* 4.5 m. high, with light purple green pseudostem	Large, oblong, 1.8 m. long × 70 cm. wide, dark green above	Medium size, sub-cylindrical, slightly curved, orange-yellow with cream-coloured pulp	*c.* 50 lb. with 10-20 hands	Good dessert quality; grown in Madras, Andhra Pradesh, West Bengal & Bihar
Cultivar: Silk (AAB) *Rasthali, Mutheli, Morthoman, Martaban, Malbhog, Sabari, Sonkel, Rasabale, Amrithapani*	Moderately stooling, tall, *c.* 3.3 m. high, with dark green stout pseudostem	Elliptic, 2 m. long × 70 cm. wide, green above & light green & glaucous below	Medium size, sub-cylindrical 4-angled, straw yellow with dull white pulp becoming creamy white on ripening, delicious taste & inviting flavour	*c.* 40 lb. with 10-12 hands	Good dessert quality; grown in Bengal, Mysore & Madras
Cultivar: French Plantain (AAB) *Nendran, Rajeli, Ethakai, Myndoli*	Robust, tall, *c.* 3.3 m. high, freely stooling; pseudostem pale green with dark brown patches	Green above, glaucous below, 2 m. long × 72 cm. wide	Large, 25 cm. long × 3.75 cm. diam., slightly curved, 3-sided, angular, yellow when young turning black on ripening; pulp salmon-yellow, firm, elastic, with conspicuously sweet core	30 lb. with 8 hands	Good dessert & cooking quality, specially suitable for chips; grown in coastal Kerala & Bombay

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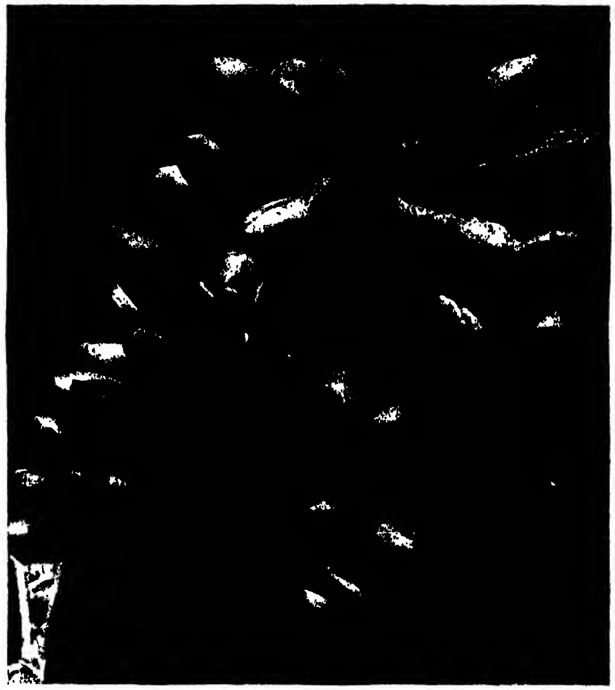

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3

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Indian Coun. Agric. Res., New Delhi

MUSA × PARADISIACA — FRUITS OF DIFFERENT CLONES

1. Poovan 2. Lal Kel 3. Basrai 4. Monthan

TABLE 2—*contd.*

Types or clones	Habit	Leaves	Fruit	Wt. of bunch	Remarks
Cultivar: Pome (AAB) *Virupakshi, Sirumalai, Vannan, Malavazhai, Dacca martaban*	Tall, stout, 4.2-4.8 m. high	Large, oblong, yellowish green	Unequally 5-sided, 5-ridged, yellowish when ripe turning dark when very ripe; pulp cream coloured, often dry, sweet, with good flavour	20-25 lb. with 6-8 hands	Good dessert quality; popular in the west coast & in Madras, mostly grown in higher elevations up to 1,500 m.
Cultivar: Ney Poovan (AB) *Ney poovan, Safed velchi, Soneri, Devabale, Puttubale*	Tall, slender, c. 4 m. high, sparsely stooling, with light green pseudostem	Linear oblong, c. 2 m. long×60 cm. broad, light green above & glaucous below	Small to medium, slender, subcylindrical; slightly curved, shining yellow, with white, sweet pulp of cottony texture	c. 34 lb. with 16-18 hands	Superior table fruit with good keeping quality; grown in Bombay, Mysore & Kerala
Cultivar: Bluggoe (ABB) *Monthan, Bankel, Khasadia, Kanchkala, Madhurangabale*	Robust, tall, c. 4.5 m. high, freely stooling, with parrot-green pseudostem	Dark green, cordate at base, 2.25 m. long×60 cm. wide	Medium to large, sharply angular, 3-5-sided, slightly curved, greenish yellow to straw-yellow colour; pulp creamy white, soft, sweetish with acid flavour	40-50 lb. with 7-8 hands	Primarily used for cooking; grown in Kerala, Madras, parts of Bengal, Bombay, Bihar & Assam
Cultiv Pisangawak (ABB) *Kostha bontha, Pey kunnan, Manuva kola*	Tall, stout, 2.7 m. high, with light green pseudostem tinged with purple	Linear oblong, glaucous below, 1.9 m. long×70 cm. wide	Fruits compact, turned towards base, terete with 4 ridges, yellow when ripe, with cream-coloured juicy & sweet pulp	8-12 hands with c. 100-120 fruits	Bunches adapted for easy handling in transport; grown in Madras, Kerala, Andhra & Assam

* Jacob, K. C., 37-133; Simmonds, 76-126.

Gros Michel, Lacatan and *Dwarf Cavendish*, which are popular commercial types. In Madras, some hybridization work has been done, involving crossing of clones within *Eumusa* section and between clones of *Eumusa* and those of *Callimusa* section. Hybrids between *Monthan* and *M. coccinea* show some improvement over the parents in the number of fruiting hands and length of fingers; the hybrids produce vigorous suckers (Shetty, *Madras agric. J.*, 1950, **37,** 145; Nair, ibid., 1953, **40,** 420; Sundararaj *et al.*, ibid., 1957, **44,** 667; Naik *et al., S. Indian Hort.*, 1959, **7,** 3; Simmonds, 410).

CULTIVATION

Bananas occupy among tropical fruits a position comparable to that of apples among temperate fruits. They are grown over wide areas throughout the tropics, from 30° N to 30° S of the equator. The major banana-growing regions of the world are: the Caribbean Islands, the central American countries, Ecuador, Colombia and Brazil in S. America, the Canary Islands, Cameroons, Ivory Coast, Ruanda Urundi, Congo and Tanganyika in Africa, India, Pakistan, Malaya, Indonesia and Philippines in Asia and a number of Polynesian Islands in the Pacific (Table 3). In India, the area under banana cultivation has been estimated at 383,000 acres; two-thirds of this area lies in Kerala, Madras, Mysore and Bombay. Table 4 summarizes the available data on the area and production of bananas in various Indian States (van Royen, I, 139; Simmonds, 131, 282; von Loesecke, 1949, 13–15).

Climate & Soil—The banana plant is cultivated mostly in the tropical belt situated within the 60°F. isotherms north and south of the equator. In India, the most satisfactory conditions for its cultivation

I.C.A.R., New Delhi

FIG. 178. FRUIT BUNCH OF HARICHAL

are found along the coastal regions of Kerala, Madras, Bombay and West Bengal. In all these areas and to a certain extent in the hill slopes of lower Palnis, Shevaroys, Wynaad and Nilgiris in South India and in Assam up to 800 m., banana is grown as a rain-fed crop. In other parts of India, it is grown under irrigation, particularly during December–March. A well-distributed rainfall of 175–250 cm. per annum is best for its cultivation, though it is able to withstand heavy rainfall of 380 cm. or more per annum. The limiting factors with regard to its large scale cultivation in several parts of North India and in some interior areas of the Deccan are the prolonged dry season requiring frequent irrigation, hot winds in summer and cool winters, with the possibility of frosts (Simmonds, 129; Cheema *et al.*, 11; Naik, 274; Gandhi, *Farm Bull., Indian Coun. agric. Res.*, No. 22, 1957).

The plant grows best in rich well-drained soil with ample moisture and decaying organic matter. It can flourish also on light sandy or gravelly soil as well as on stiff, but well-drained clays, if the soil is fertile and facilities for irrigation are available. In some districts of Madras, it is grown in paddy fields. In the vast silt deposited, high level *paduga* lands of Cauvery delta, banana flourishes well and crops for a hundred years or more (Cheema *et al.*, 9; Naik, 275; Hayes, 233; Yegna Narayan Aiyer, 285–86; Gandhi, loc. cit.; Gopalan Nair, *Banana in India, Rev. Ser., Indian Coun. agric. Res.*, No. 23, 1958).

Preparatory tillage—The soil is well dug or deeply tilled before planting though in the deltaic areas of Andhra Pradesh, planting is done without any preparatory tillage. In high level areas, terraces are made and planting is done in pits. If the soil is not rich, manuring at the time of planting is desirable (20–30 cartloads of farmyard manure/acre) and, if circumstances permit, green manuring is recommended both for heavy and light soils (Cheema *et al.*, 12; Naik, 296; Gopalan Nair, loc. cit.).

TABLE 3—ACREAGE & PRODUCTION OF BANANA IN THE MAJOR PRODUCING COUNTRIES*

	Area‡ (thousand acres)	Production§ (thousand tons)	Export§ (thousand tons)
Colombia	1,700[b]	1,800[a,d]	224
Brazil	350	4,700	215
Ecuador**	650[e]	2,000	658
Ruanda Urundi	450	1,979	..
Congo†	650	1,753	36
Tanganyika	500	1,200	..
India	383[c]	1,972[c]	..
Pakistan	100	500	..
Philippines	420	314	..
Honduras	170	855	360
Costa Rica	40	340[a]	305
Panama	35[c]	47.3[c]	285
Fr. Equatorial Africa	150	700	..
Fr. Cameroons	240[e]	470	84
Ivory Coast/Guinea	170	400	106
Canary Islands	20	279	253
Jamaica	100	202[a]	146

* *Fruit*, Commonwealth Econ. Comm., 1960, 98, Table 83; 102, Table 84.

**Data pertain to bananas; †Includes bananas and plantains; ‡Latest available data; § Data for 1957.

[a] Data for 1956; [b] Area includes mixed cultivation; [c] Includes bananas and plantains; [d] Data for plantains; [e] Data for 1958–59.

TABLE 4—ACREAGE & PRODUCTION OF BANANAS IN VARIOUS STATES IN INDIA*

	Area (acres)			Production (tons)		
	1956-57	1957-58	1958-59	1956-57	1957-58	1958-59
Kerala	116,305	116,305	116,305	311,790	311,790	311,790
Madras	77,486	74,687	74,500	551,400	610,129	531,080
Mysore	41,886	38,603	39,643	73,169	66,718	70,015
Bombay	39,006	39,006	39,006	360,369	360,369	360,369
Assam	31,950	22,750	36,500	57,053	73,103	244,420
Bihar†	20,000	20,000	20,000	100,000	100,000	100,000
West Bengal	18,700	18,700	18,700	116,800	116,800	116,800
Andhra Pradesh	17,737	22,779	19,339	162,149	209,045	173,238
Tripura	12,200	10,100	9,000	48,800	40,000	31,500
Orissa	6,832	6,423	6,423	6,563	5,996	5,996
Madhya Pradesh	2,227	2,791	2,279	22,146	23,075	17,266
Uttar Pradesh	967	1,141	1,141	7,992	9,609	9,609
Andaman & Nicobar Is.	308	326	326	336	350	350
Rajasthan	109	114	73	202	224	79
Himachal Pradesh	72	110	127	33	59	85
Total	385,785	373,835	383,262	1,818,802	1,927,267	1,972,597

* *Area and Prod. Minor (non forecast) Crops in Reorganized States*, Directorate Econ. & Statist., Minist. Food & Agric., Govt. of India.
†Shukla & Roy, *Indian J. Hort.*, 1956, **13**(1), 1.

FIG. 179. FRUIT BUNCH OF PUTTUBALE

Propagation Portions of underground tuberous stems or rhizomes and suckers formed from them are used for planting. Two kinds of suckers are produced: sword suckers with stout base, tapering top, and narrow and small leaves, and water suckers produced when the rhizome is diseased or injured or when conditions for sucker production are unfavourable. Sword suckers less than 90 cm. high, selected from healthy and mature plants are preferred for planting; larger suckers fruit early but the fruit bunches produced are generally small. Suckers are separated from the mother rhizome and planted after pruning damaged parts; often they are hardened by storing in shade for 4–5 days. In some areas, suckers are headed back before or after planting; they are sometimes dipped in a thick slush of cowdung and water and smeared with wood ash. In Kerala, suckers of *Nendran* banana are treated similarly, dried in the sun for a day or two and stored for a week before planting. In the case of *Basrai*, the parent plant is cut down after harvesting the fruits, and suckers encouraged to grow for some time. They are then dug out, roots and pseudostems removed and the resulting bulbs stored for two months before planting (Cheema *et al.*, 13; Simmonds, 161-62; Jacob, K.C., 141; Gandhi, loc. cit.; Gopalan Nair, loc. cit.; Bhan & Mazumdar, *Indian J. Hort.*, 1956, **13**, 141).

Planting—Suckers or rhizome material are generally planted in pits, 45 cm. × 45 cm. × 45 cm., dug at regular intervals. In wet land areas, suckers are sometimes planted on raised mounds. Planting on ridges with trenches on either side at a distance of 90 cm. is recommended in heavy soils. The spacing between plants depends largely on the type planted and the fertility of the soil. Dwarf types like *Basrai* are planted 1.5–2.0 m. apart which allows 1,200–1,700 plants per acre, while tall types are planted 2.7–3.0 m. apart which gives 450–550 plants to the acre (Naik, 296; Hayes, 234–35; Gandhi, loc. cit.; Gopalan Nair, loc. cit.).

The time of planting varies in different parts of the country. In Madras, *Poovan* is planted in two or three seasons to ensure crops during the greater part of the year. In the perennial plantations of Tanjore, the planting period extends from January to June and on lower Palnis and Sirumalai hills, planting is done in April. The planting period on the west coast is September to November, though in other areas of S. India planting starts at the break of monsoon in June and continues till November; in Kerala, *Nendran* is planted in December. In Thana district of Bombay with its more equable and moist coastal climate, planting is done in April, June, August or October. *Basrai* type is usually planted at the beginning of the monsoon in June in Deccan,

I.C.A.R., New Delhi

FIG. 180. BANANA PLANTATION

Marathawada, Vidarbha, parts of Gujarat and inland Saurashtra; planting in February has been recommended in some areas, since the fruits would be ready for harvest in the off-season and command a good price in the market [Naik, 295; Cheema *et al.*, 15; Gandhi, loc. cit.; Gaitonde, *Farmer*, 1956, **7**(8), 77].

Banana may be grown alone or as a mixed crop along with mango and jack. In Kerala, it is often grown in rotation with tapioca, followed by a cucurbitaceous crop. On the slopes of lower Palnis, hilly districts of northern Mysore and the plains between western ghats and the sea, banana is grown as a perennial crop often mixed with coconut, arecanut, mango and jack. It is also raised as a nurse or inter-crop in young coconut or coffee plantations and continued for 3–4 years, during which period the plants afford shade to young crops; it is often preferred as an inter-crop in young coconut plantations, since it is said to consolidate the soil and the heavy manure it receives benefits the young palms (Gandhi, loc. cit.; Cheema *et al.*, 22; Yegna Narayan Aiyar, 287; Rao, *Andhra agric. J.*, 1957, **4**, 73).

Depending upon the richness of the soil, nature of cultivation and the banana type cultivated, plantations may continue to be productive for 1–5 generations. In some deltaic areas of Godavari and Cauvery, banana plantations remain productive for as many as 50–100 years. *Lal kel*, *Basrai* and *Nendran* are grown for only one generation (Gandhi, loc. cit.).

Manuring—The banana plant is a heavy surface feeder and requires plenty of nutrients for its vigorous growth. It has been estimated that an acre of banana plantation yielding 50,000 lb. of fruits requires c. 300 lb. of nitrogen (N), 150 lb. of phosphoric acid (P_2O_5) and 100 lb. of potash (K_2O). Nitrogen influences the growth of shoots and leaves, and the number of fruits per bunch; phosphoric acid stimulates the root system, but in excess it slows down the growth of leaves and fruits; potash influences the development of the pseudostem and increases the number of hands per bunch; it also improves resistance to diseases [Cheema *et al.*, 15; Hayes, 236; Naik, 299; Katyal & Chadha, *Fertiliser News*, 1961, **6**(1), 16].

Farmyard manure or compost is usually applied to the soil during preparatory tillage, while oilcakes and artificial fertilizers are applied as top dressing to individual plants during the first 6 months after planting. Manurial practices in different banana-growing areas of India vary according to the soil, type cultivated, climatic conditions and availability of manures. In the deltaic areas, silt from the bottom of channels is applied. As a top dressing, groundnut cake is commonly employed after the monsoon in Madras while in Bombay, castor cake is popular; mustard cake is used in W. Bengal. In some of the coastal areas in Bombay, fish meal is used along with other organic manures. Inorganic fertilizers, including ammonium sulphate, superphosphate and potassium sulphate, are used in many areas, often in combination with organic manures. Good results have been reported in Bombay by the application of a mixed fertilizer containing: castor cake, 60–73 parts; ammonium sulphate, 22 parts; potassium sulphate, 9–10 parts; and superphosphate, 10–11 parts, at the rate of 7–8 lb./stool and at intervals of one month for a period of 3–4 months. In the Cauvery delta, the practice is to apply 2 cwt. of ammonium sulphate per acre about 2 months after planting, followed by 1,000 lb. of groundnut cake and 2 cwt. of ammonium sulphate in the fifth or sixth month (Cheema *et al.*, 15; Gandhi, loc. cit.; Gopalan Nair, loc. cit.; Naik, 300; Katyal & Chadha, loc. cit.).

Irrigation—The large leaves of the banana plant transpire a considerable amount of water and frequent and heavy irrigations are needed, particularly during dry periods, to keep the plants healthy and vigorous. A soaking irrigation is usually given immediately after planting and further irrigations at intervals ranging from 4–6 days to 15–20 days, depending upon climatic and soil conditions of the area as well as the vigour of the type cultivated. *Basrai* banana requires a total of 40–45 irrigations during a period of 18 months in Poona, whereas in N. Gujarat and E. Khandesh, it needs as many as 80–90 irrigations. Irrigation is generally given through channels, furrows or by flooding basins or beds around each plant. Ridge planting has proved particularly advantageous for irrigation purposes, although a large quantity of water is required (Hayes, 235; Naik, 298; Cheema *et al.*, 20; Gandhi, loc. cit.).

Post-planting operations—Weeding is an important operation in banana plantations till the plants grow up. Cover cropping with sunn hemp is recommended in heavy rainfall areas near the west coast; the cover crop can be sown at the same time as bananas and pulled out after six weeks and used for green manuring.

In localities subject to strong winds or cold waves and frosts, it is advisable to grow a hedge of closely planted trees of tall habit. When frost is imminent, the humidity inside the plantation is kept high by flooding. In Bombay and in a few other States, banana types, particularly those propagated from small bulbs and planted shallow are periodically earthed up as a protection against wind damage. Where suckers are planted fairly deep, earthing up is required for protecting sucker crops of the subsequent generation. In some areas, plants may need propping up with wooden crutches to prevent damage by winds, particularly when the fruit bunch develops and the plant becomes top heavy. In areas where damage due to sun burn is feared, the lower half-dried leaves are left as they are and bunches are covered with dried leaves; leaf blades of completely dead leaves are pruned leaving only sheaths to cover the trunk [Cheema *et al.*, 13–20; Naik, 302–03; Gandhi, loc. cit.; Phadnis & Gopalakrishna, *Indian Hort.*, 1957–58, **2**(2), 28].

As suckers compete with the mother plant for available nutrients in the soil, their number and development are usually regulated. Suckers commence to appear from about the third month of planting; they are removed as they appear and only one or two allowed to grow when the parent plant commences flowering. Desuckering is done in such a way, often with a special type of crowbar, that the bulb of the mother plant is not unduly damaged (Gandhi, loc. cit.; Gopalan Nair, loc. cit.; Naik, 304).

When the bunches have been fully formed, the bud (*Kelphul*) containing infertile flowers is cut off, a few inches beyond the last fruit cluster. The removal of the bud is reported to increase the weight of the fruit bunch. Growing bunches are covered with baskets of plaited coconut leaves in Kerala to protect them against weather and to impart an attractive light green colour. The bunches may be completely covered by bags, as is the practice in Queensland, to afford protection against frost, cold winds, scorching heat, dust and birds (Naik, 305; Gopalan Nair, loc. cit.; Simmonds, 189).

Diseases—The most serious and widespread disease of banana is Panama disease or wilt, caused by *Fusarium oxysporum* Schlecht. var. *cubense* (E.F. Smith) Wollenw. Among the types cultivated in Madras, *Poovan*, *Rasthali* and *Sirumalai* are reported to be susceptible to the disease. *Sonkel* grown in Bombay is also susceptible; it has been now replaced by *Basrai* which is immune to the disease. In Bihar, the type *Malbhog* is reported to be highly susceptible, whereas *Kothia* and *Bagner* are resistant. The disease causes wilting or drying up of leaves and longitudinal splits on pseudostem and interferes with fruit development; the rhizome is affected and so are the suckers arising from it. The disease is attributed to the presence of high subsoil water table or waterlogging conditions. As control measures, diseased plants should be pulled out and destroyed and the soil removed during the uprooting operation should be treated with quicklime. Replanting should not be carried out on infested soils for a few years and suckers from non-infected areas and preferably from non-susceptible types should be selected for replanting. Flooding the soil under 5 cm. of water for 45 days and application of lime (1 ton per acre) are stated to kill the pathogen in the soil [Gandhi, loc. cit.; Jacob, K. C., 150; Simmonds, 367–78; Cheema *et al.*, 33; Roy & Sharma, *Indian J. Hort.*, 1952, **9**(4), 39; Barthakur & Baruah, *Proc. Indian Sci. Congr.*, 1953, pt III, 73; Ramakrishnan & Damodaran, *Proc. Indian Acad. Sci.*, 1956, **43B**, 213].

Leaf spot (Sigatoka disease) caused by *Cercospora musae* Zimm. = *Mycosphaerella musicola* Leach is a serious disease of banana in the tropics. It is reported to be prevalent in Bihar, Bengal and Madras. The fungus is specific to banana and causes faint yellowish spots on leaves; in severe cases fruit development is affected. Preventive methods include spraying with Bordeaux mixture and removing affected leaves. Spraying with oil has given satisfactory results in other countries. Some clones are reported to be resistant to the disease (Roy & Sharma, loc. cit.; Simmonds, 379–94; Brooks, 209).

A leaf disease caused by *Helminthosporium* sp. has been reported from Bengal. The infection starts near the margin of the leaf, giving rise to a pale brown spot surrounded by a bright yellowish zone of drying tissue; the infection spreads to the midrib and then to the pseudostem which begins to rot. Removal and destruction of infected parts in the early stages followed by two prophylactic sprays with Bordeaux mixture are recommended (Padmanabhan, *Sci. & Cult.*, 1947–48, **13**, 509).

A rot of the pseudostem caused by *Sclerotium rolfsii* Sacc. has been reported on *Rasabale* and *Madhurangabale* from some districts of Mysore. The growth of the plant is retarded; the pseudostem splits longitudinally at the base and leaves turn yellow, droop and dry up. The disease is spread by

sclerotia which drop to the ground and remain viable for a long time in the soil. Application of Bordeaux paste to the base of the pseudostem gives effective control. Infected leaf sheaths should be removed early and before sclerotia are shed (Venkatakrishnaiah, *Mysore agric. J.*, 1946-47, **25,** 68).

Pseudostem rot, main stalk rot and anthracnose rot are caused by *Gloeosporium musarum* Cooke & Massee or *Botryodiplodia theobromae* Pat. The first disease affects newly planted suckers: pseudostems turn black and decay. Control is afforded by pulling out affected plants, dipping rhizomes in 2% copper sulphate solution for ten minutes, and replanting. Sun scorch during winter is a predisposing factor for main stalk rot disease and covering of exposed fruit stalk and bunch with dry banana leaves affords protection; rot in developing fruits can be controlled by spraying with Burgandy or Bordeaux mixture once a month. Anthracnose rot in stored fruits can be checked by careful handling of fruits and suitable fungicidal treatments [Dastur, *Agric. J. India*, 1916, **11,** 142; Simmonds, 243-44; Jain, *Nagpur agric. Coll. Mag.*, 1950-51, **25**(1), 35; Cheema *et al.*, 33; Gandhi, loc. cit.; Chona, *Indian J. agric. Sci.*, 1933, **3,** 673].

Bunchy top is a virus disease of banana transmitted to healthy plants by the aphid *Pentalonia nigronervosa* Coq. It is prevalent in Kerala and Assam, and is reported to be spreading to Bombay; it is also prevalent in a few other parts of India. The virus is systemic in the plant and affects suckers. Diseased plants remain stunted and leaves are bunched together to form a rosette at the top. Most banana types are susceptible to the disease. Methods of control include: removal and burial or burning of affected plants and prohibiting by law the movement of planting material from diseased areas to healthy ones. A virus disease causing heart-rot has been reported from Bihar. Affected leaves have a mosaic-like appearance; the virus spreads to the heart leaf and even the corm may get affected. Control measures recommended for bunchy top are also effective against heart-rot (Gandhi, loc. cit.; Roy & Sharma, loc. cit.; *Rep. Dep. Res., Univ. Travancore*, 1939-46, 98; Richards, *Trop. Agriculturist*, 1951, **107,** 229; Jacob, K. C., 148).

Pests—Over 180 insects, 7 mites and 6 eelworms are reported to attack banana. Only half a dozen of them cause any serious damage to crops in India. Banana weevil or borer, *Cosmopolites sordidus* Germ., is the most wide-spread among them. The grubs bore into the rhizome and destroy tissues; the plant sometimes falls down. Old corms of the stool serve as breeding ground for the pest and 20-30 grubs may be found in the same stool. The adult weevil is found in the soil and deposits eggs in decaying leaf bases or on the crown of the corm. Control measures include destruction of infected pseudostems and corms, and using only suckers free from infestation for planting. Borers may be trapped by cutting across the stump of the harvested pseudostem at ground level and replacing the severed portion in the original position when borers collect between cut surfaces. Poison baits containing Paris green mixed with flour may be used to kill beetles. Application of dry Dieldrin mixed with gypsum powder (or fertilizer) around the base of clump affords effective control (Simmonds, 335-63; Roy & Sharma, loc. cit.; Sen & Prasad, *Indian J. Ent.*, 1953, **15,** 240; *Trop. Abstr.*, 1958, **13,** 703).

Banana stems are sometimes riddled by grubs of *Odoiporus longicollis* Oil. Adult as well as immature forms occur in leaf sheaths all the year round. The pest is controlled by removing infested plants and burning [Lal, *Agric. Anim. Husb., Uttar Pradesh*, 1950, **1**(4), 30].

A chrysomelid beetle, *Nodostoma viridipennis* Motsch., is reported to attack leaves and also fruits in Bihar. Spraying with Pyrocolloid and Guesarol 550 is recommended as a control measure (Roy & Sharma, loc. cit.; Sen & Prasad, loc. cit.).

Harvesting—Depending upon the season of planting, cultural conditions, type of banana and size of suckers used, the inflorescence appears 8–18 months after planting. January plantings are said to flower later than June plantings. The time taken from flowering to harvesting of fruits in South India is 80–110 days for early types, 120-150 days for medium types and 150–170 days for late types. Under intensive cultivation in Kerala, *Nendran* banana can be harvested within nine months of planting (Yegna Narayan Aiyer, 290; Naik, 305).

The bunches are ready for harvest when fruits become plump and attain a light green colour: at this stage they give a characteristic sound when struck with the knuckle and dried floral ends drop off with the slightest touch of the hand. The time taken for attaining full maturity has been worked out for several types, and as the date of setting of the bunch is known, the time of harvesting can be

readily calculated; in some countries, the date of emergence of the fruit is stamped on the bunch. The bunches are cut, along with a piece of stalk 45–60 cm. in length to facilitate handling. The parent plant is usually removed soon after harvesting, but the practice known as "mattocking" where the parent pseudostem is retained for a month and then cut down to ground level is said to be beneficial to the development of followers (suckers) which yield bumper bunches (Yegna Narayan Aiyer, 290; Gandhi, loc. cit.; Simmonds, 190; Nayar *et al.*, *Indian J. Hort.*, 1956, **13**, 210).

Though banana plants bear fruit all the year round there are certain periods in the year which can be regarded as the harvesting season when supplies of fruit to the markets are at their peak. Speaking generally, the harvesting season is August-December. In Mysore, bananas are available throughout the year except the month of July. Heavy harvests are obtained from October to April in Madras, from June to September in Travancore and from September to February in Bombay, while in Assam, the harvesting season extends from May to September with a peak in June-July (*Agric. Marketing India, Rep. Marketing Bananas, Marketing Ser.*, No. 49, 1945, 6–7).

Yield—In terms of both harvest weight (4–8 tons/acre) and calories (2.8–5.6 million calories/acre), the yield of banana per acre ranks higher than that of many other tropical fruit crops. The yield is calculated on the basis of the number of bunches harvested per acre and also the number of hands and fingers borne on each bunch. Some 100 types of banana are grown in Coimbatore and among them *Poovan* contains the largest number of fruits (180 fruits) per bunch, while *Myndoli* gives the highest crop yield, viz. 57 lb. per plant. *Nendran* yields 30–50 fruits per bunch, the estimated acre yield being 700 bunches. In Tiruchirapalli the yield per acre of *Poovan* is estimated at 1,000 bunches in the first year, 800 in the second and 700 in the third, each bunch weighing 25–40 lb. The average yield of *Basrai* per acre in Bombay is 450-500 md., and may reach 700–750 md. under favourable conditions. In the perennial *paduga* plantations in Tanjore, the yields reported are: *Poovan*, 375–500 md.; *Vamankeli*, 300 md.; and *Monthan* and *Rasthali*, 250 md./acre [*Fruit*, Commonwealth Econ. Comm., 1960, 97; Massal & Barrau, 17; *Rep. Marketing Bananas*, 1945, 5; Naik, 305–06; Phadnis & Gopalkrishna, *Farmer*, 1957, **8**(9), 33; Gandhi, loc. cit.].

Bananas are not allowed to ripen on the plant, but are ripened after harvesting. In India, ripening is effected usually by smoking. In Madras and Bombay, the bunches or hands are heaped in a closed room and covered with plantain leaves; cowdung cake is lit in one corner of the room and smoking continued for 36–48 hours when the colour of the fruit changes from green to faint greenish yellow; bunches are then stored in well ventilated godowns where they ripen to a perfect yellow in 2–3 days. In some places, a mud plaster is applied over the heap and fire lit in a mud pot placed below the heap so that smoke and moist heat spread through the layers of fruit. In Nilgiris and in Bihar, bananas are smoked in underground pits. In Assam, bunches are ripened either by exposing them to the sun or over a hearth or by storing in paddy godowns. Application of vaseline to the cut end of the stalk not only protects the bunch from infection but also favours early ripening of fruit with a uniform and attractive colour (Gandhi, loc. cit.; *Rep. Marketing Bananas*, 1945, 20–21; Naik, 306).

The practice in America and Europe is to ripen fruits in specially constructed chambers in which heating and ventilation are controlled. Fruits are ripened for 12–24 hr. at 60–68°F. in summer and 70–75°F. in winter and the temperature then reduced to 60–62°F. Ethylene is often used to accelerate ripening (Wardlaw, *Trop. Agriculture, Trin.*, 1937, **14**, 70; von Loesecke, 1949, 45–49; Simmonds, 217).

Bananas ripened by smoking or heating in closed chambers are not so sweet as those ripened slowly over a period of a week or two at 60–70°F. under cold storage. Fruits ripened under cold storage do not show freckling or black spots which are common in fruits ripened by smoking (Gandhi, loc. cit.).

Under cold storage (68°F.) freshly harvested *Basrai* takes 3 weeks to ripen and *Mutheli* or *Rasthali* takes 2 weeks. *Sirumalai* and *Karpura chakkarakeli* take 3–5 weeks for ripening at 56°F.; *Basrai* gets chilled and spoiled at 56°F. (Karmarkar & Joshi, *Indian Fmg*, 1940, **1**, 173; *Mem. Dep. Agric. Madras*, No. 36, 1954, 357; Gandhi, loc. cit.).

Storage—Optimum conditions for the storage of *Dwarf Cavendish* are 52–56°F. and R.H. 85–90%, the approximate storage life being 22 days; *Gros Michel* is not affected by chilling to 52°F. no matter how rapidly the temperature is lowered, provided the temperature of the delivery air is not below 52°F. Chilled bananas do not soften normally and develop darkened areas and unpleasant flavours. Refrigerated

gas storage in an atmosphere of 5% carbon dioxide and 5–7% oxygen and removal of volatiles by an alkaline solution of potassium permanganate is said to increase storage life. Waxing of fruits with a mixture of waxes like Ceremul retards ripening as well as shrinkage (Kirpal Singh & Mathur, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1952–53, **2**, 307; Wardlaw, loc. cit.; Chandler, 414–16; *Rep. Marketing Bananas*, 1945, 29; Kapur & Hall, *Proc. Indian Sci. Congr.*, 1956, pt III, 402; von Loesecke, 1949, 55–59).

Utilization and Composition

Banana is one of the most important fruit and vegetable crops of India. Not only is it cultivated on a large scale as a field crop but it is also widely grown as a backyard crop in households. In certain parts of Kerala, in many Pacific Islands and in tropical Africa, banana forms a staple food of the people. Fresh fruit is eaten as dessert, while unripe fruit and fruit from cooking types are eaten as vegetable. Fruit pulp is dried and processed into flour or preserved in many forms for subsequent use. Fruits are used in various Indian confections like *rasayanam* and *panchamrutam*, sugar-coated chips, toffee, coffee substitutes, jams and jellies. It is also canned (Jacob, K. C., 155–64; Simmonds, 260–66; Massal & Barrau, 17–18).

The ripe fruit is a rich source of carbohydrates and a fair source of minerals and vitamins, particularly of the B group. The composition varies with type and also the stage of maturity. Analysis of the flesh of 59 types of ripe banana from Madras (percentage of flesh in fruit, 52.1–91.8) gave the following values: moisture, 60.6–79.8; protein, 0.4–1.7; reducing sugars, 3.6–24.6; non-reducing sugars, 0.0–14.6; other carbohydrates, fat, etc., 0.1–16.4; and ash, 0.7–1.6%; calorific val., 67–137 cal./100 g. Table 5 gives the composition of the flesh of some popular dessert types of Indian bananas.

The analytical values for the pulps of 8 types of unripe banana used for culinary purposes in Madras were as follows: moisture, 60.4–72.4; protein, 1.0–1.8; reducing sugars, 0.1–0.2; non-reducing sugars, 0.5; other carbohydrates (mostly starch) and fat, 24.5–36.7; and ash, 0.9–1.3% (Jacob, K. C., 165, 196–211; Simmonds, 256).

Starch (amylose, 20.5%) constitutes the major carbohydrate of green unripe banana. As the fruit ripens, the starch is rapidly hydrolysed into soluble sugars and the percentage of total sugars increases from 1–2 in green banana to 15–20 in the ripe fruit.

TABLE 5—CHEMICAL COMPOSITION OF THE PULPS OF SOME RIPE BANANAS GROWN IN INDIA

Type	Locality	Edible matter %	Moisture %	Protein %	Reducing sugars %	Non-reducing sugars %	Starch + fibre + ether extr. %	Ash %
Lalvelchi	Bombay†	85.1	74.7	1.0	15.2	2.7	1.4	0.7
Poovan	S. India*	77.8	73.8	1.1	19.8	0.2	4.3	0.9
Basrai	Bombay†	69.9	75.1	1.1	9.2	8.8	1.8	1.0
Vamankeli	S. India*	71.7	78.5	1.0	10.0	5.0	4.6	0.9
Harichal	Bombay†	75.3	75.5	0.9	10.9	7.5	0.9	1.0
Pedda pacha arati	S. India*	76.5	75.3	1.4	14.9	4.3	2.8	1.3
Mutheli	Bombay†	81.8	71.2	1.0	9.6	8.4	2.3	0.8
Rasthali	S. India*	84.0	71.3	1.7	15.5	3.4	7.0	1.2
Safed velchi	Bombay†	86.5	65.9	0.9	13.5	9.1	4.5	1.0
Ney poovan	S. India*	91.8	65.9	1.0	23.6	4.1	4.3	1.0
Lal kel	Bombay†	75.3	72.7	0.8	5.4	13.3	3.2	0.9
Chenkadali	S. India*	79.3	75.0	1.5	7.1	13.8	1.7	0.9
Rajeli	Bombay†	72.7	65.6	1.1	14.0	7.1	6.9	0.9
Nendran	S. India*	78.8	64.1	0.4	23.9	2.5	8.2	0.9
Bankel	Bombay†	74.7	80.0	..	4.1	6.7	..	..
Monthan	S. India*	77.7	71.6	1.0	15.2	3.7	7.1	1.4

† Information from Horticulturist, Dep. Agric., Bombay.
* Jacob, K. C., 196–211.

Sucrose, glucose and fructose are the principal sugars; maltose is present and four other sugars have been spotted chromatographically but not identified (Simmonds, 225–26; Bates *et al., J. Amer. chem. Soc.*, 1943, **65**, 142; Lulla & Johar, *Curr. Sci.*, 1955, **24**, 92).

The total pectin content of Indian banana, calculated as calcium pectate, is *c.* 4.2%. Insoluble pectic substances are progressively transformed during ripening into soluble substances; a decrease in total pectic substances is observed in the post-ripening stage. The hemi-cellulose content decreases during ripening. Small amounts of lignin and cellulose are reported to be present in the ripe fruit (Krishnamurti & Giri, *Proc. Indian Acad. Sci.*, 1949, **29B**, 155; Kertesz, 293; von Loesecke, 1949, 90–91).

The principal proteins of the banana are an albumin and a globulin; glutelin, prolamines and proteoses are also present. The amino acid composition of the proteins of two types of bananas is given in Table 6; the composition of casein is included for comparison. Free amino acids identified in the ripe fruit are: arginine, asparagine, aspartic acid, glutamine, γ-amino butyric acid, pipecolic acid, leucines and traces of serine, glycine, glutamic acid and threonine. Feeding trials on experimental rats have shown that banana proteins are comparable to rice proteins in quality (von Loesecke, 1949, 102, 144; Rao *et al., J. sci. industr. Res.*, 1956, **15C**, 39; Bhagavan & Rajagopalan, *Curr. Sci.*, 1956, **25**, 223; *J. sci. industr. Res.*, 1957, **16C**, 115).

TABLE 6—AMINO ACID COMPOSITION OF THE PROTEINS OF RIPE BANANAS*

(Calculated to g./16 g. nitrogen)

	Pachabale	*Rasabale*	Casein
Cystine	1.7	2.3	0.3
Lysine	5.8	6.6	6.0
Histidine	8.3	7.1	2.5
Arginine	6.1	5.3	3.8
Serine, glycine & aspartic acid	12.9	15.6	9.6
Threonine & glutamic acid	15.4	17.4	25.4
Alanine	5.6	6.8	1.9
γ-Amino butyric acid	4.3	6.2	..
Tyrosine	8.5	6.3	6.6
Methionine & valine	6.8	10.6	11.3
Phenylalanine	2.4	4.8	3.9
Leucine & *iso*leucine	6.7	9.0	9.7

*Bhagavan & Rajagopalan, *Curr. Sci.*, 1956, **25**, 223.

The essential amino acids present in the proteins of green plantain (crude protein, 2.71%) are as follows (expressed in g./16 g.N): arginine, 4.13; histidine, 4.46; *iso*leucine, 5.12; leucine, 5.42; lysine, 5.60; methionine, 0.63; phenylalanine, 4.53; threonine, 2.73; tryptophan, 0.74; and valine, 4.35; methionine is the limiting amino acid. The amino acid composition is similar to that of potato and sweet potato, except that the histidine content is high (Ramachandran & Phansalkar, *Indian J. med. Res.*, 1956, **44**, 501).

Banana contains a small amount of fatty oil which does not suffer any change during ripening. Ether extraction of the dried material yields a dark brown oil having the following characteristics: $n_D^{40°}$, 1.4648; iod. val., 82; and unsapon. matter, 14.4% (von Loesecke, 1949, 105).

Banana is a fair source of calcium and iron and a rich source of potassium, magnesium, sodium and phosphorus. Analysis of the ripe fruit gave the following values: sodium, 34.8; potassium, 401.0; calcium, 9.0; magnesium, 28.0; manganese, 0.8; copper, 0.2; iron, 0.6; phosphorus, 31.0; sulphur, 10.0; chlorine, 125; and silica, 23.8 mg./100 g. Minor elements reported to be present are: iodine, aluminium, zinc, cobalt and arsenic. The ash is alkaline in reaction. Green plantain contains: calcium, 10; phosphorus, 30; iron, 0.6; potassium, 382; and sodium, 67 mg./100 g. (von Loesecke, 1949, 144, 105; Kar, *Sci. & Cult.*, 1938–39, **4**, 76; Winton & Winton, II, 505; *Hlth Bull.*, No. 23, 1951, 40; Pain & Banerjee, *Indian J. med. Res.*, 1956, **44**, 749).

Analysis of the pulp of 8 types of South Indian bananas for vitamins gave the following ranges of values: carotene (as vitamin A), 8–470 i.u.; thiamine, 20–51 μg.; riboflavin, 21–71 μg.; niacin, 0.5–0.8 mg.; and ascorbic acid, 5–17 mg./100 g.; pantothenic acid, pyridoxine, biotin, inositol, folic acid and minor amounts of tocopherols are present. Of the total ascorbic acid, 20–30% is dehydroascorbic acid. A part of the acid is lost during cooking; partially ripe fruits lose 10% and fully ripe fruits 50–75% of the acid (Information from the Director, Nutr. Res. Lab., Coonoor; *Hlth Bull.*, No. 23, 1951, 40;

von Loesecke, 1949, 114; Gomez & Mattill, *Food Res.*, 1949, **14,** 177).

The unripe fruit is astringent to the taste. The flesh of the mature fruit just beginning to ripen contains 1.52–1.66% tannin, while the peel contains much more. During ripening the tannins probably pass over into bound insoluble forms and the free tannin content decreases. Leuco-delphinidin and leuco-cyanidin have been identified in the fruit (Ranganathan, *J. Indian Inst. Sci.*, 1928, **11A,** 80; von Loesecke, 1949, 97–101; Simmonds, 228).

Green banana skin contains chlorophyll (51.7–102.9 mg./kg.), carotene (1.2–3.7 mg./kg.) and xanthophylls (5.2–7.3 mg./kg.). During ripening the colour of the peel changes to yellow and the chlorophyll content decreases to almost zero. Analysis of the pulps of *Lal kel* and *Basrai* bananas (from Bombay) gave respectively the following values: xanthophyll, 2.2, 1.0; neo-β-carotene U, 0.3, 0.1; and β-carotene, 2.6, 0.6 μg./g. (von Loesecke, 1949, 108–09; Sadana & Ahmad, *J. sci. industr. Res.*, 1949, **8B,** 35).

The aroma and flavour characteristic of the banana develop during ripening. Amyl acetate is the principal odorous constituent; amyl butyrate, acetaldehyde and ethyl and methyl alcohols have been identified. Fresh pulp contains 0.0013% total volatile oil. Ethylene is produced during the climacteric (von Loesecke, 1949, 107; Simmonds, 229).

l-Malic acid is the principal acid present in the free state in ripe banana; citric and oxalic acids are also present. Boric, tartaric, acetic and butyric acids have been reported in some types. Nine types grown in India have been examined and none of them contained acids other than citric and malic. During the ripening of fruit, the free malic acid content increases (from 0.053 to 0.373% in one type examined) (von Loesecke, 1949, 94–96; Harris & Poland, *Food Res.*, 1937, **2,** 135; Lulla & Johar, *Curr. Sci.*, 1954, **23,** 362).

The enzymes present in banana include amylase, invertase, protease, catalase, peroxidase, lipase, oxygenase, phosphatase and ascorbic acid oxidase. The activities of the enzymes vary greatly during the ripening of the fruit; catalase activity decreases while invertase activity increases. Histological examination of ripening banana has shown that the disappearance of starch begins at the periphery and gradually extends towards the core, thus indicating that the peel is the seat of amylase. The pulp probably contains activators of amylase; pulp extracts exhibit little or no activity, while a mixture of extracts of peel and pulp shows greater activity than either of them alone. Tannin has an inhibitory action on banana amylase (von Loesecke, 1949, 114–18; Sastri & Row, *Proc. Indian Acad. Sci.*, 1934–35, **1B,** 318).

Bananas contain comparatively large amounts of two physiologically important compounds, namely, serotonin (5-hydroxytryptamine) and norepinephrine, in addition to dopamine (3, 4-dihydroxy phenylethylamine), 3, 4-dihydroxy phenylalanine (?) and an unidentified catecholamine. The concentrations of some of the compounds in the pulp and peel of ripe yellow bananas have been reported to be as follows: *pulp*—serotonin, 8–50 μg./g.; norepinephrine, 1.9 μg./g.; and dopamine, 7.9 μg./g.; *peel*—serotonin, 47–93 μg./g.; norepinephrine, 122 μg./g.; and dopamine, 700 μg./g. Serotonin inhibits gastric secretion and stimulates smooth muscle in the intestine and elsewhere; norepinephrine is a mediator of autonomic function and is widely used as a vasoconstrictor agent. Serotonin is apparently well tolerated when administered orally to human beings: doses up to 20 mg. of serotonin caused no adverse effect. The therapeutic uses of banana (in coeliac disease, constipation, peptic ulcer, etc.) may be due to the presence of these active principles (Waalkes *et al.*, *Science*, 1958, **127,** 648).

Peel—The peel which forms 8.2–47.9% of the fruit, depending upon the variety and stage of ripeness, is used as cattle feed. It is reported to be comparable to hay of good quality in nutritive value. Analysis of the peel gave the following values (dry basis): crude protein, 6.1; ether extr., 8.7; crude fibre, 10.0; N-free extr., 63.1; total sugars (as invert sugar), 22.0; and ash, 12.1%; the ash is rich in potassium salts. Sun-dried peel contains the following vitamins: β-carotene, 1.66 mg.; α-tocopherol, 3 mg.; nicotinic acid, 5 mg.; and ascorbic acid, 138 mg./100 g.; riboflavin, traces (Jacob, K. C., 165, 196–211; Archibald, *J. Dairy Sci.*, 1949, **32,** 969; *Chem. Abstr.*, 1951, **45,** 6317).

Banana peel is a potential source of pectin. Peels of green, yellow and brown bananas are reported to contain respectively, 0.51, 0.38 and 0.46% soluble pectic substances and 1.28, 1.02 and 0.81% total pectic substances (Kertesz, 294, 414).

The skin and pulp of green banana contain antifungal substances, while the skin and pulp of the

ripe banana contain both antifungal and antibacterial substances ; an active principle which inhibits pathogenic fungi has been separated. The peel contains serotonin, norepinephrine, and related compounds in higher proportions than the pulp. An antibacterial factor active towards acid-fast bacteria (*Mycobacteria*) is present in fully ripe banana (Schaffer *et al., Yearb. Agric. U.S. Dep. Agric.*, 1950–51, 732 ; Waalkes *et al.*, loc. cit.).

The peel of green banana yields *c.* 2% of a milky white latex which contains tannins ; a chicle-like gum which dries to a brown, tacky, odourless and tasteless mass (softening pt., 44°) is present in a concentration of *c.* 10% in the latex. Analysis of the gum gave the following values: moisture, 11.46 ; acetone-sol. resins, 44.45 ; ether extr., 34.36 ; alban, 13.61 ; fluavil, 15.35 ; protein, 2.38 ; and ash, 0.39% (von Loesecke, 1949, 35–36).

Flowers—The neutral and staminate part of the inflorescence before it opens (Hindi & Beng.—*Mocha* ; Tam.—*Vazhaipu*) is used as a vegetable. Analysis of the edible part gave the following values: moisture, 90.2 ; protein, 1.5 ; ether extr., 0.2 ; carbohydrate, 5.0 ; fibre, 1.9 ; and mineral matter, 1.2% ; calcium, 0.03 ; and phosphorus, 0.05% ; iron, 0.1 mg. ; and nicotinic acid, 0.6 mg./100 g. The flower extract shows antibacterial activity against *Micrococcus pyogenes* var. *aureus*. Diglycosides of delphinidin and cyanidin are present in brown red bracts (Hayes, 246 ; *Hlth Bull.*, No. 23, 1951, 40 ; Joshi & Magar, *J. sci. industr. Res.*, 1952, **11B**, 261 ; Ponniah & Seshadri, ibid., 1953, **12B**, 605).

Banana stem—The tender inner portion or core of the stem (Beng.—*Thor* ; Tam.—*Vazhai thandu* ; Kan.—*Bale dindu* ; Mal.—*Vazha pindi*) of fruited banana plant is sold as vegetable and eaten after cooking. It contains: moisture, 88.3 ; protein, 0.5 ; fat, 0.1 ; carbohydrates, 9.7 ; fibre, 0.8 ; mineral matter, 0.6 ; calcium, 0.01 ; and phosphorus, 0.01% ; iron, 1.1 mg. ; and nicotinic acid, 0.2 mg./100 g. ; carotene, nil. Green stems, leaves and rootstock provide succulent feed for cattle and sheep. Outer sheaths are used as fodder for elephants. The stalk is used as mulch after crushing and shredding in a mill. Stalks and leaves are also used as manure ; they contain: N, 0.61 ; P_2O_5, 0.12 ; and K_2O, 1.01%. Stem sap, as also the juice of other parts of the plant, stain cloth almost black and the stain is fairly fast to washing ; the sap may be used as a substitute for marking ink (Hayes, 246 ; *Hlth Bull.*, No. 23, 1951, 40 ; von Loesecke, 1949, 125 ; Sahasrabuddhe, *Bull. Dep. Agric. Bombay*, No. 174, 1934, 15 ; *Leafl. Dep. Agric. Bombay*, No. 1, 1919, 1).

Fresh pseudostems contain up to 5% (av. 2%) starch which can be extracted and used for edible purposes. It forms a transparent paste with water and is considered useful for finishing textiles. The starch content varies with clone, stage of growth and season. For the extraction of starch, stems are cut longitudinally and the juice pressed out with the help of a cane crusher ; the residual fibrous material is worked up with water in a paper pulp beater and the extracts so obtained is added to the press juice. The combined suspension containing starch is strained through sieves and tabled (Subrahmanyan *et al., J. Sci. Fd Agric.*, 1957, **8**, 253 ; Jain *et al.*, ibid., 1956, **7**, 61).

Peeled leaf sheaths are used fresh or after drying as packing material for flowers, betel leaves, fruits, etc. They are stripped into shreds, dried and used for tying packages and making garlands. Banana fibre has been locally used in India for cordage purposes, mats, and to a small extent, for making coarse paper. The yield of fibre from cultivated plants varies from 0.29 to 2.5 oz. per stem. Some of the types yield fibres of good strength and quality. For the extraction of fibre, the sheath layers are separated soon after cutting the plant and the pulpy matter scraped off with a blunt piece of iron ; the pulpy matter adhering to the fibre is removed as quickly as possible by washing or boiling with alkaline soap. The fibre is washed and spread out to dry. Exposure to sun in a damp state imparts a brownish yellow tinge which is not readily bleached. The fibre may be softened by treatment with potassium or sodium carbonate solution (1%). Treated fibre (yield, 70% of raw dry fibre) resembles linseed fibre in softness and feel and possesses satisfactory strength (Naik, *Indian J. Hort.*, 1945, **3**, 14 ; *Mem. Dep. Agric. Madras*, No. 36, 1954, 358 ; Biswas & Athawale, *J. Instn Chem. India*, 1946, **18**, 96).

Efforts have been made to utilize banana fibre for the production of paper pulp. Digestion with dilute nitric acid followed by caustic soda yields a pulp (yield, 44%) which can be easily bleached. Optimum conditions for pulping have been worked out. A process has been developed for the production of fibre board from banana stalk (Kane & Marathe, *J. Indian chem. Soc., industr. Edn*, 1949, **12**, 113 ; *Chem. Abstr.*, 1949, **43**, 9450).

Leaves—Banana leaves are used extensively in India as platters. In some districts of Madras, the

plant is often cultivated for leaves as well as fruits: the types *Nalla bontha, Monthan, Poovan, Rasthali* and *Elavazhai*, are the types preferred for leaf production and plants in the field are given an additional dose of groundnut cake at 1 lb. per stool to stimulate leaf formation. About 20 leaves per month can be harvested from each stool for six months from the eighth month onwards. When a crop is raised for fruits and leaves, fruits are harvested in the first year and the ratoon crop exploited for leaves in the second year. The income from the leaf crop is often higher than that from the fruit crop (Jacob, K. C., 144, 146; Sundararaj, *Madras agric. J.*, 1952, **39,** 13).

Medicinal uses—Banana fruit possesses mild laxative properties. The sugars present tend to increase Gram-positive or acidic groups of micro-organisms in the intestines and decrease Gram-negative organisms. The fruit aids in combating diarrhoea and dysentery and promotes the healing of intestinal lesions in ulcerative colitis. Banana powder is effective in the treatment of coeliac disease, sprue and other forms of carbohydrate intolerance in children; it is used for certain intestinal disorders in adults. It forms a useful constituent of the diet of infants: a syrup prepared of the ripe fruit may be incorporated with milk and used for infant feeding. The ripe fruit is reported to be useful in diabetes, uremia, nephritis, gout, hypertension and cardiac diseases. Unripe fruit and cooked flowers are useful in diabetes. In China, the stalk of fruited plant is given to pigs for eliminating kidney worm (*Stephanurus dentatus*). The ash of the root, as also that of the entire plant, is anthelmintic. The juice of flowers is used for dysentery and stem and root for disorders of the blood (Jacob, K. C., 147, 162–64; von Loesecke, 1949, 143–49, 125, 132; Kirt. & Basu, IV, 2452–54; Simmonds, 271).

Banana Products

Chips—Fully mature but unripe banana is cut into chips, like potato, and consumed after frying in oil. *Nendran, Monthan, Sambrani monthan* and *Kaio* are the types preferred for this purpose. Fried *Nendran* chips are reported to keep well for 2–3 months. A product with a pale colour is obtained when slices are cut by a stainless steel knife: the slices are dipped in acidulated water, washed with water and dried in the sun or in a home drier at 140–45°F. after exposure to sulphur dioxide fumes for an hour (Jacob, K. C., 161, 42; *Brochure on Home-Scale Food Preparation Series*, Cent. Fd technol. Res. Inst., Mysore, 1959, No. 32; Simmonds, 263).

Flour & Powder—Banana flour is prepared from unripe fruit and banana powder from ripe fruit. The former is essentially starchy, while the latter is rich in sugars. For the preparation of flour, dried banana chips are powdered in a mill and sifted through sieves (yield, 12.5–27.55% of fresh fruit). Analysis of banana flour (from five Madras types) gave the following values: moisture, 10.2–10.9; carbohydrates, 79.6–83.3; protein, 2.8–4.9; ether extr., 0.4–0.9; fibre, 0.7–1.4; and ash, 2.0–3.0% (Jacob, K. C., 157–58; *Mem. Dep. Agric. Madras*, No. 36, 1954, 358; von Loesecke, 1949, 128).

Banana flour is used as infant food in Malabar: it is given in the form of gruel. Flour from *Kunnan* and *Nendran* types are preferred for the purpose. Vermicelli and cakes are also prepared from the flour. It is used in the preparation of a variety of sweet and savoury dishes and, in admixture with wheat flour, for making bread and biscuits (Jacob, K. C., 159; *Brochure on Home-Scale Food Preparation Series*, Cent. Fd technol. Res. Inst., Mysore, 1959, No. 32; *Mem. Dep. Agric. Madras*, No. 36, 1954, 358).

Banana powder is prepared from the pulp of ripe fruits after mashing and drying in drum or spray driers. The dried product is pulverized and passed through a 20-mesh sieve. Analysis of powder from over-ripe *Poovan* banana gave the following values: total sugars, 68.8; starch, 7.2; protein, 5.0; ether extr., 0.4; crude fibre, 1.5; pectin (as calcium pectate), 2.5; acidity (as citric acid), 2.2; and ash, 3.1%. Banana powder may be used also in the preparation of beverages of the malted milk type (Subrahmanyan *et al.*, *Ann. Biochem.*, 1957, **17,** 155; von Loesecke, 1949, 132).

Figs—Banana fig is the popular name for dried ripe fruits. For making figs, peeled fruits are split longitudinally, each half cut into pieces about 1 inch in length and dried in the sun till pliable and soft. Figs keep well for 3–4 months. A product with attractive appearance and good keeping quality is obtained by dipping banana pieces for 15 min. in sodium carbonate solution (1%), followed by washing in water, exposure to sulphur dioxide fumes for an hour and drying in a cabinet drier at 55–60°. Juicy varieties are generally preferred for preparing figs: *Pey kunnan* and *Chakkarakeli* are used in Madras and *Rajeli* in Bombay. Banana figs have a

sweet taste and contain 50% or more of reducing sugars. They are consumed as such or in puddings and beverages (Jacob, K. C., 155 ; Das *et al.*, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1954–55, **4**, 281 ; Cheema *et al.*, 28).

Confections—In South India, ripe fruit is used in the preparation of confections, e.g., *Panchamrutham, Pazhaprathaman* and *Rasayanam*. The ingredients for *panchamrutham* are banana pulp, honey, ghee, sugar candy and spices. It has a delicious taste and is used as an offering to deities in temples. *Rasayanam* is made by cutting the fruit into chunks over which is poured sugar and a small quantity of ghee. Chunks may be mixed with sugar (25–30%), acidified with citric acid and canned in sealed tins (*Rep. Marketing Bananas*, 1945, 30 : Jacob, K. C., 52 : *Brochure on Home-Scale Food Preparation Series*, Cent. Fd technol. Res. Inst., Mysore, 1959, No. 53).

Fermentation products—Banana pulp is sometimes employed for making alcoholic beverages. Banana flour can satisfactorily replace malt in brewing to the extent of 20%. Vinegar has been prepared (yield, 48–53%) by fermenting a mash of banana pulp and peel (Simmonds, 263 ; von Loesecke, 1949, 137–39).

Production and Trade

The total world production of bananas is estimated at 8–9 million tons per annum of which about 3.0–3.5 million tons enter international trade : tropical American and African countries contribute the major share. The annual production in India is estimated at 1.7–2.0 million tons. Most of it is consumed within the country for table purposes : a small quantity (*c.* 0.7%) is used for the production of banana flour, figs, etc., and a still smaller quantity is exported, mainly to countries bordering the Persian Gulf (Table 7) (*Fruit*, Commonwealth Econ. Comm., 1960, 98, 102).

Banana bunches are sold by growers to contractors or merchants and transported loose in bullock carts, motor lorries or by rail to markets. A lining of plantain leaves is provided on the floor and sides of the cart or wagon ; sometimes each bunch is wrapped in banana leaves. In Madras, the hands of hill bananas (*Virupakshi* or *Sirumalai*), from which the fruits get easily detached when ripe, are separated from the bunch, wrapped in dried leaves and arranged with interlining of leaves. In some areas, the hands are packed in gunny bags holding *c.* 2 md.

TABLE 7—EXPORTS OF FRESH BANANAS FROM INDIA
(Qty in cwt.)

Country	1957	1958	1959
Bahrein	16,446	22,261	15,601
Trucial Oman	3,664	2,119	3,376
Saudi Arabia	2,563	5,717	5,615
Kuwait	839	2,679	1,806
Others	98	192	85
Total Qty (cwt.)	23,610	32,968	26,483
Total Val. (Rs.)	390,150	478,918	439,522

or in wicker baskets holding 32 lb. In Cochin, small parcels of *Nendran* banana are despatched in baskets made of splits of *Lantana* shrub (*Rep. Marketing Bananas*, 1945, 30–35, 18).

Specifications for the grading of bananas and adoption throughout the country have not been formulated. In Madras and Mysore, bunches are graded into five classes according to the number of fingers in each bunch. Tentative grade specifications for hill bananas have been evolved in Madras (*Rep. Marketing Bananas*, 1945, 21–22).

The consumer demand for different types of bananas varies in different regions. *Poovan* and *Champa* are popular throughout Madras, Mysore, Bengal and Assam ; they have an attractive appearance and keep well, though they are slightly sour to the taste. *Sirumalai* or *Virupakshi* and *Rasthali* of Madras, *Chakkarakeli* of Andhra, *Rasabale* of Mysore, *Morthoman* and *Amritsagar* of Bengal and *Lal kel* of Bombay possess good taste and flavour and are popular. *Basrai* and *Harichal* types are in great demand in Bombay and N. Indian centres. *Nendran* banana of Malabar are used for dessert as well as cooking purposes: they are specially preferred for preparing chips and are, sometimes, exported to Middle East countries in exchange for dates. *Monthan* (otherwise known as *Madhurangabale* or *Khasadia*) is grown in almost all States and used for cooking (*Rep. Marketing Bananas*, 1945, 11, 37 : Jacob, K. C., 42).

M. textilis Nee Manila Hemp, Abaca

D.E.P., V, 302 ; C.P., 790 ; Fl. Br. Ind., VI, 263 ; Moore, *Baileya*, 1957, **5**, 185 ; Jacob, K. C., 130, Pl. 74, 75.

Tam. & Mal.—*Naaru vazhai ;* Kan.—*Natal bale.*

A tall, stout, stoloniferous plant, 2.5–4.0 m. high, native of the Philippines, introduced and experi-

mentally tried in India for its fibre. Leaves broadly oblong, leathery, firm in texture, bright green above, glaucous beneath, often with large brown spots: fruits compact, nearly terete, 5–7 cm. long × 2.0 cm. diam., with pale cream coloured inedible pulp filled with many seeds. This species is valued for its fibre, extracted from leaf sheaths of the mature plant, and known in the trade as *Manila Hemp*.

M. textilis (chromosome number n = 10) belongs to the *Australimusa* section of the sub-genus *Musa*. It crosses with difficulty with *M. acuminata* or *M. balbisiana* and only when it is used as the male parent. It includes more than 20 recognized clones differing somewhat in fibre characteristics and growth habits: a few natural hybrids (*M. balbisiana* × *M. textilis*) are also known (Cheesman, *Kew Bull.*, 1949, 267; Spencer, *Econ. Bot.*, 1953, **7,** 195).

Experimental cultivation of *M. textilis* has been tried in West Bengal, Madras and Andaman Islands, but the results so far obtained have not proved particularly promising. Cultivation trials were renewed in Madras during World War II; the yield of fibre from plants was rather low and uneconomical; the fibre was inferior not only to standard manila hemp but also to the fibre extracted from some locally cultivated banana types, like *Nendra padathi*, *Pacha nadan*, *Vannan*, *Nana nendran*, *Kuri bontha*, etc. The plant has been reported to thrive well in Andamans, but little attention seems to have been paid to cultivation and fibre extraction. The prospects for manila hemp production in Andamans appear promising and further efforts have been recommended (*Bull. imp. Inst., Lond.*, 1909, **7,** 10; Naik, *Indian J. Hort.*, 1945, **3,** 14; Sircar, *Misc. Bull., Indian Coun. agric. Res.*, No. 66, 1948, 15; Jacob, K. C., 132; *Mem. Dep. Agric. Madras*, No. 36, 1954, 358).

M. textilis is extensively cultivated in the Philippines. It thrives in well-drained, moderately rich loams at elevations of 60–150 m. with an annual average rainfall of 250–275 cm. evenly distributed throughout the year. It is propagated by suckers or from parts of mature rootstock containing one or more growing buds. The plant may be raised from seeds but this method is rarely employed as seeds are of low viability and seldom produce plants true to the parents. The average yield of fibre per stalk is 1 lb. and the annual average yield per acre, 1,000–2,000 lb. in the Philippines (Matthews, 370–75; Spencer, loc. cit.).

Abaca plant is susceptible to bunchy top, mosaic and wilt diseases; it is also liable to attack by the banana borer *Cosmopolites sordidus* Chev. Measures recommended for the control of similar diseases and pests of banana are also effective against abaca diseases and pests (Matthews, 372; Spencer, loc. cit.)

Fibre—The harvested stalks of the plant are utilized for the extraction of fibre. The fibre is located primarily adjacent to the outer surface of the leaf sheath. Each leaf sheath consists in cross section of 3 layers, the outer fibrous layer, the middle containing a small quantity of fine white fibre, and the inner layer which contains no fibre at all. The outer sheaths of the stalk contain fibres which are strong but distinctly brown or dark in colour, while the inner sheaths give soft white fibres which are pale white in colour; the fibres nearer the base are stronger than those near the tip (Weindling, 40; Himmelfarb, 36; Spencer, loc. cit.).

The fibre consists of strands ranging in length from 0.9 to 2.7 m.; those extracted for the full length of the middle sheaths may be as long as 4.5 m. Each strand is made up of bundles of fibre cells, 3–12 mm. long × 16–32 μ. diam., irregularly round or oval with tapering ends; they are smooth and lustrous with long distinct lumens. The fibre is stronger than hemp (from *Cannabis sativa*) and sunn hemp (from *Crotalaria juncea*), which are the commonly used cordage fibres, and possesses good elongation and flexing qualities. It is highly resistant to micro-organisms, particularly those present in saline waters. It contains 60–70% α-cellulose and resembles jute in chemical composition (Harris, 70).

Abaca fibre as met with in commerce varies in colour from almost pure white, through cream to light or dark brown, according to the position of the sheath in the stalk from which the fibre is derived and the care taken in extracting and processing the fibre. It is used mainly for twines, ropes and cable; it is much valued for hawsers, ships' cables and riggings. The best grades of binder twine are made of abaca, and fine strands of the fibre are spun into thread and used in coarse weaving and upholstering; fine fabrics are also made. Old manila ropes and waste are useful in the manufacture of tough paper. In Japan, heavy paper used for construction of movable walls are made from abaca (Matthews, 379; Spencer, loc. cit.).

The largest producer of abaca in the world is the Philippine Islands with an annual production of

TABLE 8—IMPORTS OF ABACA FIBRE INTO INDIA

	Qty (tons)	Val. (thousand Rs.)
1956	1,083	1,864
1957	1,034	1,796
1958	1,126	1,843
1959	1,115	2,248
1960	1,368	3,138

nearly 100 thousand tons. Small quantities are produced by Indonesia and some countries of Central America. India imports annually *c.* 1,000 tons of abaca valued at 1.8–3.1 million rupees mainly from the Philippines (Table 8) (Spencer, loc. cit.).

Besides the species dealt with above, there are three or four other exotic species, which are of interest either as ornamental plants or as possible breeding material. *M. ensete* or Abyssinian Banana is one of them; its characteristics have been briefly referred to in Table 1 along with wild Indian species some of which are also grown for ornamental purposes.

M. basjoo Sieb. & Zucc. ex Iinuma is a sparsely stooling ornamental plant, native of Japan, with spreading rhizomes, bearing greenish yellow fruits containing black, warty, compressed seeds. It is resistant to cold and is well adapted for growing in gardens in cool climates. It resembles *M. itinerans* Cheesman with which it is stated to be closely allied genetically (Cheesman, *Kew Bull.*, 1948, 323; Simmonds, ibid., 1956, 463; Moore, *Baileya*, 1957, **5**, 179).

M. coccinea Andr., a free stooling plant with numerous green pseudostems, 1.5 m. high, and bearing an erect inflorescence with bright scarlet, persistent bracts, is cultivated in India and elsewhere for its short stature and ornamental effect. It is a native of Indo-China and belongs to the section *Callimusa*. It bears oblong, orange-yellow fruits containing black cylindrical seeds, *c.* 6 mm. long, with warty ridges [Cheesman, *Kew Bull.*, 1950, 29; Moore, *Baileya*, 1957, **5**, 181; Gopalaswamiengar, 341; Gowder & Nambisan, *Indian Hort.*, 1958–59, **3**(2), 8].

M. fehi Bert. ex Vieill. comprises a group of 3 or 4 wild or semi-domesticated species occurring in Pacific Islands, grown more for ornament than for their edible fruits. They belong to the section *Australimusa* and bear plumpy fruits with yellow or yellowish green pulp. The fruits are unpalatable when raw and are eaten after cooking. The sap of the plant is reddish violet and contains an anthocyanin pigment stable to light; it is sometimes used as a dye. The leaves are used as platters and for making cigarette paper (Cheesman, *Kew Bull.*, 1949, 445; Moore, *Baileya*, 1957, **5**, 172; Simmonds, 73–74).

Muscovite — *see* **Mica**

Mushroom — *see* **Fungi**

Musk — *see* **Deer**

Musk Mallow — *see* **Hibiscus**

Musk Melon — *see* **Cucumis**

Musk Plant — *see* **Mimulus**

Musk Root — *see* **Ferula**

Musk Seed — *see* **Hibiscus**

MUSSAENDA Linn. (*Rubiaceae*)

A genus of shrubs, rarely herbs, distributed chiefly in the tropical and sub-tropical regions of the Old World. About 15 species occur in India; a few exotics are cultivated in gardens.

The ornamental species of the genus are very pretty in flower. One of the calyx lobes develops into a large, white or coloured leaf-like structure which makes the plant conspicuous and attractive. *Mussaenda* species are generally hardy and are propagated by seeds, cuttings or layers (Firminger, 500; Bor & Raizada, 82).

*M. frondosa Linn.

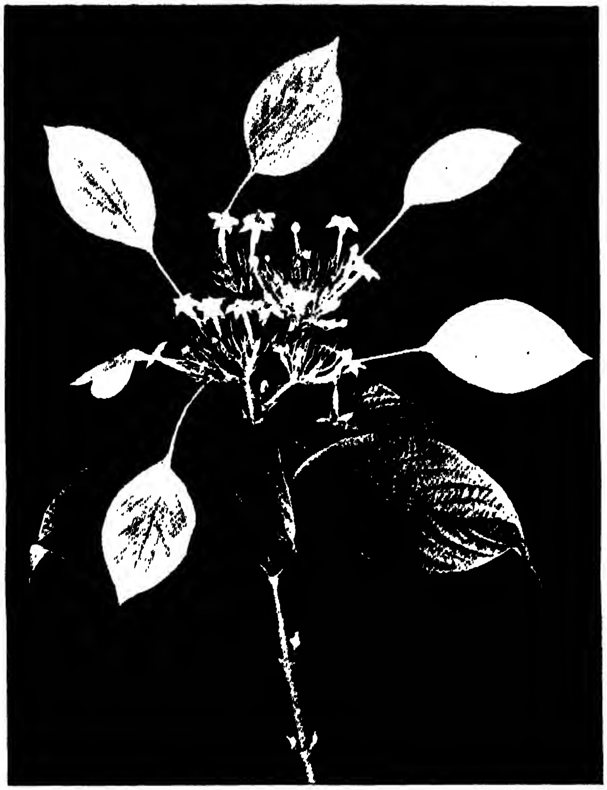
D.E.P., V, 308; Fl. Br. Ind., III, 89.

HINDI—*Bedina, bebina*; BENG.—*Nagballi*; MAR.—*Bhutkes, bhurtkasi, lavasat*; TAM.—*Vellaiyilai, vellimadandai*; KAN.—*Billoothi, pathri, hasthygida*; MAL.—*Parathole, vellila*.

NEPAL—*Asari*; LEPCHA—*Tumberh*.

A handsome erect or scandent shrub, sometimes a small tree, found in tropical Himalayas from Dehra Dun eastwards, Khasi hills, Deccan Peninsula, and Andaman Islands; it is commonly cultivated in gardens. Bark grey; leaves elliptic-oblong or ovate; flowers in terminal cymes, tubular-funnel shaped, yellowish green outside and orange red within, one

* *M. frondosa* of Fl. Br. Ind. embraces a number of varieties which have been raised to specific rank; they are not discriminated for medicinal or other uses.



F.R.I., Dehra Dun. Photo : M. N. Bakshi

FIG. 181. MUSSAENDA FRONDOSA—FLOWERING BRANCH

calyx lobe occasionally becoming white and foliaceous; berries sub-globose or ovoid.

The leaves as well as the foliaceous calycine lobes of flowers are eaten as pot-herb. Leaves are used also as manure. The wood (wt., 36 lb./cu. ft.) is white, soft to moderately hard, close- and even-grained; it is used locally for turning and for making spoons, ladles and other small articles. The leaves of the plant and also flowers are used in external applications for ulcers. A weak decoction of dried shoots is given to children to relieve cough. The bitter root is considered alterative and demulcent and used in the treatment of white leprosy and eye troubles (Rama Rao, 207; Gamble, 410; Talbot, II, 94; Cowen, 105; Kirt. & Basu, II, 1271).

M. glabra Vahl

Fl. Br. Ind., III, 90.

ASSAM *Charai-atha, chuba-atha, sonarupa*; MUNDARI—*Kula marsal.*

A large, scandent, often climbing, shrub found in tropical Himalayas from Nepal eastwards, Bihar, Bengal and Assam, ascending to an altitude of 1,500 m. Leaves elliptic or oblong-lanceolate, coriaceous, sometimes mottled; flowers in terminal cymes, yellow; berries globose.

The plant is often grown in hedges. Young leaves are said to be appetizing and eaten in salads and chutneys. Leaves are chewed with betel and are used as infusion to relieve cough: a decoction of the root is used for the same purpose. The flowers are reported to possess diuretic properties and used in asthma, recurrent fevers and dropsy (Burkill, II, 1519).

M. erythrophylla Schum. & Thonn. is an ornamental scandent shrub grown in gardens, particularly on the hills, for its bright green leaves and yellow flowers with showy, scarlet calycine lobes. The root is said to be useful in coughs: it is also chewed as an appetizer (Dalziel, 405).

M. luteola Delile is a pretty shrub with dull green foliage, yellow flowers and foliaceous sepals. It is a native of Africa, commonly grown in Indian gardens; it is suitable for hedges (Seth & Pande, *Bull. Uttar Pradesh For. Dep.*, No. 27, 1957, 22).

M. roxburghii Hook. f. (ASSAM *Soklati*) is a large ornamental shrub found in tropical Himalayas from Nepal eastwards and in North Bengal and Assam. It is grown in gardens and is suitable for hedges. The leaves are eaten as vegetable. An infusion of leaves is used for colouring baskets (Seth & Pande, loc. cit.; Fl. Assam, III, 47).

Mussels — *see* **Molluscs**

Mustard — *see* **Brassica**

MYRIACTIS Less. (*Compositae*)

D.E.P., V, 309; Fl. Br. Ind., III, 247.

A small genus of erect annuals, including four species recorded in India. Of these, *M. wallichii* Less. (ASSAM *Baberi*) occurs in the temperate Himalayas from Simla to Sikkim at altitudes of 2,700-3,600 m. and in Aka hills in Assam. It is an erect, pubescent herb, 30-90 cm. high, with ovate or lanceolate leaves, 2.5-10.0 cm. long, and yellow flowers in small, hemispherical heads. The leaves and young shoots of the plant are eaten in Assam, either boiled or fried in oil.

MYRICA Linn. (*Myricaceae*)

A genus of shrubs or trees distributed in the temperate and sub-tropical regions of both hemispheres, except Australia. One species occurs in India.

M. esculenta Buch.-Ham. syn. *M. farquhariana* Wall.; *M. sapida* Wall.; *M. nagi* Hook. f. (Fl. Br. Ind.) in part, non Thunb. BOX MYRTLE

D.E.P., V, 309; III, 448; Fl. Br. Ind., V, 597; Fl. Malesiana, Ser. I, **4**(3), 278.

HINDI—*Kaiphal*; BENG.—*Kaiphal, satsarila*; MAR.—*Kaya phala*; GUJ.—*Kariphal*; TEL.—*Kaidaryamu*; TAM.—*Marudam*; KAN.—*Kirishivani*; MAL.—*Maruta*.

PUNJAB—*Kaiphal, kahela, kahi*; KUMAON—*Kaphal*; NEPAL—*Kobusi*; ASSAM—*Naga-tenga*; KHASI—*Soh-phi*; LUSHAI—*Keifang*.

A small or moderate-sized evergreen tree, 3–15 m. high, found in sub-tropical Himalayas from Ravi eastwards to Assam and in Khasi, Jaintia, Naga and Lushai hills at altitudes of 900–2,100 m. Bark grey or brownish grey, rough with deep vertical wrinkles; leaves lanceolate, oblong-obovate; flowers minute, unisexual, in axillary spikes; fruit an ellipsoid or ovoid drupe of the size of cherry, tubercled, reddish or cheese-coloured when ripe, with rugose nut.

The fruits of the plant are edible. They have a pleasant sourish sweet taste and are used in the preparation of a refreshing drink. The fruits are covered with a crust of white waxy material, permeated with brown and black spots. Some of the other species of the genus, e.g. *M. cerifera* Linn. of America and *M. cordifolia* Linn. of Africa, are richer sources of wax, and it can be easily separated by boiling the fruits in water. The material so obtained is not a true wax, but a vegetable tallow composed largely of glycerides. It is used for making candles and soaps, and also in various formulations for polishing leather. Fruits are considered pectoral, sedative, stomachic and carminative [Bor, 112; Krishna *et al.*, *Indian For. Rec.*, *N.S.*, *Chem.*, 1936, **1**(1), 39; Williams, *Econ. Bot.*, 1958, **12,** 103; Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37,** 1009].

FIG. 182. MYRICA ESCULENTA—FLOWERING AND FRUITING BRANCHES

The bark of *M. esculenta* contains a yellow colouring matter and is rich in tannin; it has been used occasionally as a tanning and dyeing material. It produces on mordanted wool shades similar to those obtained with quercitron bark (from *Quercus* sp.); on mordanted cotton, it produces shades similar to those obtained with old fustic (*Chlorophora tinctoria*). The yellow colouring matter, myricetin (hexahydroxy flavone, $C_{15}H_{10}O_8$, m.p. 350–57°) occurs in the bark in the form of the glycoside, myricitrin (myricetin 3-rhamnoside, $C_{21}H_{20}O_{12}$, m.p. 199–200°). A second glycoside, the aglycone of which is possibly quercetin, is present in traces. Some specimens of bark are exceedingly rich in colouring matter. The tannins of the bark belong to the pyrogallol group and *c.* 73% of the total tannins can be extracted with water. Hides tanned with box myrtle bark tend to be cracky; they are somewhat darker in colour than those tanned with wattle bark. Analysis of bark gave the following values: moisture, 10.5; tannins, 32.1; soluble nontans, 10.7; and insolubles, 46.6%; tan: nontan ratio, 2.9 (Karrer, 628; Perkin & Everest, 220–23; Santhanam & Barat, *Bull. cent. Leath. Res. Inst.*, *Madras*, 1960–61, **7,** 20).

The bark of the plant is astringent, carminative and antiseptic. A decoction of the bark is considered useful in asthma, diarrhoea, fevers, lung affections, chronic bronchitis, dysentery and diuresis. The bark is chewed to relieve toothache and a lotion prepared from it is used for washing putrid sores. The bark is reported to be used in Khasi hills as a fish poison (Chopra, 1958, 515, 605, 679; Nadkarni, I, 829).

MYRICARIA Desv. (*Tamaricaceae*)

A small genus of shrubs or subshrubs distributed in Europe and temperate Asia. Two species occur in India.

M. elegans Royle

D.E.P., V, 310; III, 430; Fl. Br. Ind., I, 250; Kirt. & Basu, Pl. 100.

PUNJAB—*Humbu, umbu*; KUMAON—*Wombu*.

An erect shrub, 3.0–4.5 m. high, found along banks of streams in the inner dry ranges of the western Himalayas from Ladakh to Kumaon and western Tibet at altitudes of 1,800–4,500 m. Leaves oblong-lanceolate; flowers pink or white, in lateral and terminal spike-like racemes.

The twigs are browsed by goats and sheep. The wood serves as a good fuel. Leaves are used as an external application to bruises (Gamble, 47; Kirt. & Basu, I, 251).

M. bracteata Royle syn. *M. germanica* Dyer (Fl. Br. Ind.), non Desv.

D.E.P., V, 311; III, 430; Fl. Br. Ind., I, 250.

PUNJAB—*Bis, shalakat, kathi.*

An erect shrub, 1.2–2.4 m. high, found often growing gregariously in sandy river beds and banks, in the inner dry ranges of temperate and alpine Himalayas from Punjab to Sikkim at altitudes of 1,500–4,200 m. Leaves linear-lanceolate; flowers pink, in spike-like racemes.

The branches are used as fodder for sheep and goats. The wood is hard and white and affords a good fuel (Gamble, 48).

MYRIOPHYLLUM Linn. (*Haloragaceae*)

Fl. Br. Ind., II, 432; Blatter, II, Pl. 62, Fig. 4.

A small genus of aquatic herbs found throughout the world. Five species occur in India.

M. spicatum Linn. is a glabrous, nearly submerged herb with only the flower-spikes appearing above the surface found in western Himalayas from Kashmir to Kumaon up to 1,800 m. Leaves whorled, pinnately divided: segments simple, hair-like; flowers yellow, in terminal spikes. The plant is recommended for fever in China. The leaves contain myriophyllin and colouring matter (Roi, 396; Wehmer, II, 865).

MYRISTICA Boehmer (*Myristicaceae*)

A genus of trees distributed from India and S.E. Asia to North Australia and the Pacific Islands. About 5 species occur in India including *M. fragrans*, the source of two valuable spices, Nutmeg and Mace.

A large number of species originally included under this genus have been assigned to *Gymnacranthera, Horsfieldia* and *Knema* (q.v.). In the present account only the species comprising the section *Eumyristica* are dealt with.

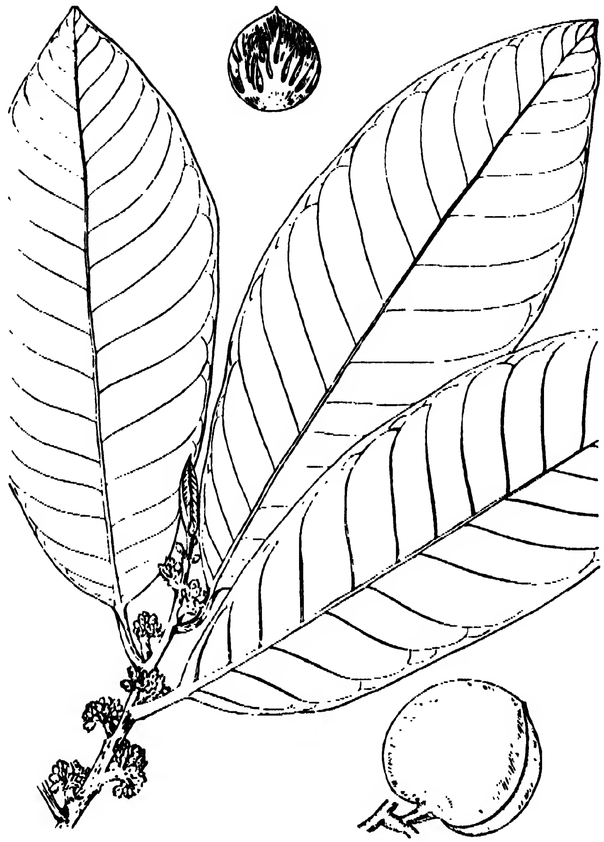


FIG. 183. MYRISTICA BEDDOMEI—FLOWERING BRANCH AND FRUIT

M. beddomei King syn. **M. laurifolia* var. *lanceolata* Hook. f.

Fl. Br. Ind., V, 103; King, *Ann. R. bot. Gdn Calcutta*, 1891, **3**, 291, Pl. 118.

MAR.—*Jayaphal;* TAM.—*Katjathikai;* KAN.—*Jajikai;* MAL.—*Patthapanu.*

A large evergreen tree, up to 27 m. in height and 2.2 m. in girth, found in western ghats from Konkan southwards and in Anaimalai and Nilgiri hills up to an altitude of 1,500 m. Leaves oblong or elliptic-lanceolate; flowers in cymes, dioecious; fruits subglobose (c. 6 cm. diam.), borne singly or in pairs; seeds globose with red, fleshy aril extending to the apex.

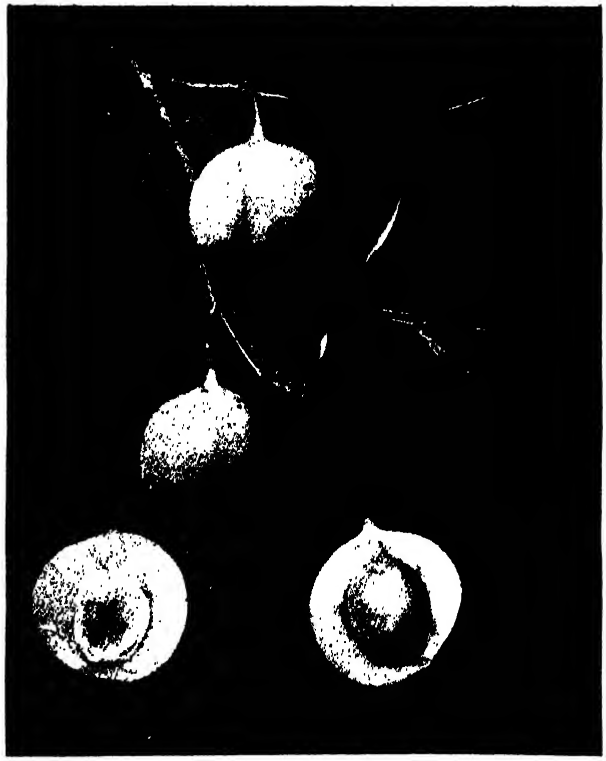
The tree is considered useful for providing shade in cardamom plantations. It has been tried as a possible rootstock for the vegetative propagation of *M. fragrans* [Abraham, *Indian Fmg, N.S.*, 1957–58,

* *M. laurifolia* Hook. f. & Thoms. is considered by most authors to be found only in Ceylon.

7(9), 14; Sundararaj & Varadarajan, *S. Indian Hort.*, 1956, **4,** 85].

The seed kernel (*Jayaphal*) on extraction with benzene yields 25% of a light yellow fat with the following characteristics: m.p. 40°; iod. val., 43; and unsapon. matter (containing resin acids), 1%; separation of the fat between 80% ethanol and petroleum ether (b. p. range 60–70°) gave 3% alcohol-soluble resin. The refined fat contains 89% fatty acids corresponding to 93% triglycerides; the component fatty acids consist of: palmitic, 2; stearic, 60; oleic, 35; and linoleic, 3%: *glyceride composition*—trisaturated, trace; di-saturated mono-unsaturated, 88; monosaturated di-unsaturated, 10; and tri-unsaturated, 2% mol. The fat differs from other *Myristica* fats in containing stearic acid as the predominant saturated acid and not myristic acid (Kartha & Narayanan, *J. sci. industr. Res.*, 1958, **17B,** 283).

The wood of *M. beddomei* is reddish grey, compact, moderately hard and heavy (wt., 52–54 lb./cu. ft.); it is perishable. It is suitable for tea boxes, match boxes and splints (Talbot, II, 380; Gamble, 556; Rama Rao, 340).



I.C.A.R., New Delhi

FIG. 184. MYRISTICA FRAGRANS—FRUITING BRANCH AND FRUIT SECTIONS

M. fragrans Houtt. NUTMEG TREE

D.E.P., V, 311; C.P., 791; Fl. Br. Ind., V, 102.

HINDI, BENG., MAR. & GUJ.—*Jaiphal* (fruit kernel), *japatri, jotri, jayapatri* (aril): TEL., TAM., KAN. & MAL.—*Jajikai, jadikai* (fruit kernel), *jadipattiri, japatri* (aril).

A dioecious or occasionally monoecious evergreen, aromatic tree, usually 9–12 m. high, but sometimes reaching a height of 20 m. or more. Bark greyish black, longitudinally fissured in old trees; leaves elliptic or oblong-lanceolate, coriaceous; flowers in umbellate cymes, creamy yellow, fragrant; fruits yellow, broadly pyriform or globose, 6–9, cm. long, glabrous, often drooping: pericarp fleshy, c. 1.25 cm. thick, splitting into 2 halves at maturity; seed broadly ovoid, arillate, albuminous, with a shell-like purplish brown testa; aril red, fleshy, laciniate.

M. fragrans is a native of Moluccas, now cultivated in many tropical countries of both hemispheres. In India, it is grown in Madras State (Nilgiris, Coimbatore, Salem, Ramanathapuram, Tirunelveli, Kanyakumari and Madurai districts); a few trees are found in various localities in Kerala, Assam and other States. Preliminary trials have shown that Araku valley (Andhra Pradesh) and Wynaad (Madras State) are well suited for its cultivation. The total number of trees in India may not exceed 1,500; of these about 500 are found in Burliar in Nilgiri dist. and Courtallam in Tirunelveli dist. (Guenther, V, 59–63; Burkill, II, 1524–27; Krishnamurthi, 171; Khan, *Madras agric. J.*, 1949, **36,** 512; Information from the Director of Agriculture, Madras; *Mem. Dep. Agric. Madras*, No. 36, 1954, 637).

M. fragrans requires a hot and moist climate with a rainfall of 150–300 cm. per annum. It grows best at low elevations in alluvium formed of deep friable loam with good drainage, well sheltered from high winds; it does not thrive above an altitude of 750 m. (Nicholls & Holland, 271–72; Krishnamurthi, 171; *Mem. Dep. Agric. Madras*, No. 36, 1954, 637).

The plant is propagated from seeds. Fresh seeds with shells, collected from mature fruits and dried for a day, are sown either directly at the site or in nursery beds, sheltered from wind and strong sun. The viability of fresh seeds is 98% in shade and 92% in the open, while that of sun-dried seeds stored for c. 2 months is only 7% in shade and almost nil

in the open. Seeds are sown 30 cm. apart, c. 2.5 cm. below the soil in nursery beds and take 1½–3 months to germinate. The seedlings are transplanted when 60–90 cm. high to their permanent site in the field during wet weather. In Nilgiris, 6 month-old seedlings are potted and allowed to grow for a year before planting in the field. The spacing between trees varies from 6 to 7.5 m., depending upon the gradient and fertility of the soil; wider spacing is adopted in rich level lands. Young plants require shade; this is provided by growing bananas in advance of planting; *Gliricidia* sp. and *Canarium commune* may also be grown. Nutmeg may also be cultivated as a mixed crop in orchards and in coffee, tea, coconut, arecanut and rubber plantations. Post-planting operations consist mainly of weeding the field and removing epiphytic and parasitic plants, and providing a mulch of dry leaves. Practically no manuring is done in India [*Mem. Dep. Agric. Madras*, No. 36, 1954, 638; Krishnamurthi, 171–72; Khan, *Indian J. Hort.*, 1945, **3**, 43; Nicholls & Holland, 272–73; Abraham, *Indian Fmg, N.S.*, 1958–59, **8**(3), 33].

The plants are generally dioecious; occasionally male trees after a number of years produce female flowers and eventually become female. In plantations raised from seeds there are usually more male than female trees and there is no means of determining the sex until the plants are 6–7 years old and begin to bear flowers. In order to ensure a sufficient number of female trees in the plantation, two seedlings are planted close together and the one which may subsequently prove to be the female is retained. In case there are too many male trees in a plantation, they may be headed back and grafted with scions from female trees. Grafting may be made on seedlings of species other than those of *M. fragrans*; in S. India, trials have shown that *M. beddomei* and *M. malabarica* are useful as seedling stock (Burkill, II, 1527; Krishnamurthi, 171; Nicholls & Holland, 274; Sundararaj & Varadarajan, *S. Indian Hort.*, 1956, **4**, 85).

Vegetative propagation by cuttings has been advocated not only to overcome the trouble and delay in selecting female trees, but also for multiplying high yielding and disease-resistant types. Trials carried out in Grenada (West Indies) have shown that hardwood and semi-hardwood cuttings, 30–38 cm. long × 0.6 cm. diam., planted in suitable rooting media after treatment with 0.05% indolyl butyric acid, give satisfactory rooting. Trials carried out at Burliar on grafting, layering and raising of plants by cuttings have not yielded any positive results (Nichols & Pryde, *Trop. Agriculture, Trin.*, 1958, **35**, 119; Sundararaj & Varadarajan, loc. cit.; *Mem. Dep. Agric. Madras*, No. 36, 1954, 639).

A fruit rot of half ripe fruits, caused by *Diplodia natalensis* Pole-Evans has been recorded at Burliar. Spraying with Bordeaux mixture and eradicating the sources of infection are recommended as control measures (Ramakrishnan & Damodaran, *Indian Phytopath.*, 1954, **7**, 7).

Harvesting & Yield—Under favourable conditions, the tree commences to bear fruit from the seventh year or earlier and the yield increases up to the fifteenth year or beyond. Trees continue to bear for many years and 70–80 years old trees are known to give good and sustained yields. At Burliar, because of its higher elevation, the trees come to bearing about 12 years after planting. Fruits are borne more or less throughout the year but the main harvesting season is June–October; in some parts of Indonesia, 2 or 3 crops are harvested in a year. Only ripe fruits in which the pericarp has split are collected. They are picked up every morning from the ground or are gathered from trees by the use of a long stick to which a hook is attached. Seeds that drop out of split fruits are also gathered. The average annual yield per tree at Burliar is 1,250 fruits, although in certain years and from some trees as many as 4,000 fruits per tree have been obtained. Yields up to 20,000 fruits per tree per year have been reported in other countries [Nicholls & Holland, 277; *Mem. Dep. Agric. Madras*, No. 36, 1954, 639; U.S.D., 1955, 873; Cobley, 208; Stanford, 479; Krishnamurthi, 172; Abraham, *Indian Fmg, N.S.*, 1957–58, **7**(8), 28; Information from the Director of Agriculture, Madras].

Preparation of nutmeg & mace—The harvested ripe fruit with the valves split, discloses the seed with a shell-like testa covered by a scarlet fibrous aril. After collection, the pericarp is removed and the seed separated from the aril and dried. Drying is complete when the kernel rattles in the shell. The shells are cracked off with wooden hammers or by suitable mechanical means and the kernels removed and sorted. Dried kernels constitute the nutmeg of commerce. In Indonesia, the kernel is usually limed before drying; liming prevents insect attack and improves the storage life of nutmeg. Mace is the dried fibrous aril covering the testa. It is obtained by separating the arils and drying in the sun after

flattening between boards; if the weather is cloudy, drying is effected in sheds using artificial heat. Mace of superior quality is produced by drying in specially constructed ovens. In some countries, salt water is sprinkled over the drying arils: this treatment is reported to improve the storage life of the mace. During drying the arils at first become dark red and brittle, and in about 6 weeks they take on a pleasing bright amber colour (Nicholls & Holland, 277; Krishnamurthi, 172; *Mem. Dep. Agric. Madras*, No. 36, 1954, 640; U.S.D., 1955, 873; Trease, 244, 248; Grist, 266-67; Burkill, II, 1528).

The trade recognizes two principal types of the spices: East Indian nutmeg and mace from Indonesia, the chief producing areas being Moluccas, northern Celebes, Sangih Islands, and west and north Sumatra including the Island of Nias, and West Indian nutmeg and mace, obtained mainly from the Island of Grenada, lying north of Trinidad. Only very small quantities are produced in Malaya. East Indian nutmeg and mace are of better quality and are highly valued in the Indian trade (Guenther, V, 60-63; Burkill, II, 1526 27).

Nutmeg—Commercial nutmeg is ovoid, 2.0–3.5 cm. long × 1.5–2.8 cm. diam., greyish brown in colour with minute reddish brown spots and lines, and reticulately furrowed. The cut surface has a waxy lustre and a mottled appearance. It has a strong aromatic odour and a pungent aromatic taste. Nutmeg is official in I.P. (Wallis, 228; I.P., 399; U.S.D., 1955, 873).

East Indian nutmeg is available in three grades: (*i*) Banda nutmeg, considered to be the finest for use and containing up to 8% essential oil; (*ii*) Siauw nutmeg, almost as good as Banda, but containing *c.* 6.5% essential oil; and (*iii*) Penang nutmeg, which is usually wormy and moldy and suitable only for distillation purposes; Papua nutmeg is derived not from *M. fragrans* but from the allied species *M. argentea* Warb.: it is sometimes classed as the fourth grade of East Indian nutmeg and can be distinguished from the true nutmeg by its comparatively long size, peculiar shape, absence of external spots, poor aromatic odour and acrid taste. Bombay nutmeg is obtained from *M. malabarica*; it is long and narrow in shape and nearly destitute of aroma; it is used as an adulterant of true nutmeg. Fictitious nutmeg is prepared from exhausted or damaged nutmeg; the material is moulded into shape and sometimes used as an adulterant of true nutmeg (Guenther, V, 60; Wallis, 229; Wren, 250).

Composition—Analysis of nutmeg gave the following values: moisture, 14.3; protein, 7.5; ether extr., 36.4; carbohydrates, 28.5; fibre, 11.6; and mineral matter, 1.7%: calcium, 0.12; and phosphorus, 0.24%; iron, 4.6 mg./100 g. Nutmeg contains a volatile oil (6–16%), starch (14.6–24.2%), pentosans (2.25%), furfural (1.5%) and pectin (0.5–0.6%). The principal constituents are a fixed oil, a volatile oil and starch. The flavour and therapeutic action are due to the volatile oil. According to the specification of the Health Ministry, Government of India, nutmeg spice shall contain: total ash, ⋗5%; non-volatile ether extr., ⋖25%; and crude fibre, ⋗10%: for medicinal use, it should contain not less than 5% volatile oil and not more than 3% ash (*Hlth Bull.*, No. 23, 1951, 44; Thorpe, VIII, 628; Guenther, V, 72; Wehmer, I, 345; I.P., 399–400).

Oil of nutmeg—The percentage of volatile oil in nutmeg varies from 6 to 16%, according to the origin and quality of the spice. A sample from Travancore gave 10.2% volatile oil. Wormy nutmegs give a much higher yield than do sound ones: in the former, most of the fixed oil, present in the endosperm which tends to retain the volatile oil during distillation, would have been devoured by worms, while the strongly aromatic oil in the inner layer of perisperm remains intact. Commercial oil is derived from broken and wormy nutmegs. The material is comminuted, pressed to remove fixed oil, and immediately subjected to steam-distillation. Loss of volatile oil from ground nutmegs is relatively rapid (*c.* 80% in 2 months). Cohobation of distilled waters may be necessary for the recovery of the total oil (Guenther, V, 71–72; Trease, 247–48; Nair *et al.*, *Proc. Indian Sci. Congr.*, 1949, pt III, 102).

Oil of nutmeg is a mobile, almost colourless or pale yellow liquid with a characteristic odour. On ageing, it partly resinifies and becomes viscous. The physico-chemical properties of oils from different sources are summarized in Table 1. The aroma of East Indian oils is much more pronounced and more characteristic of the spice than that of West Indian oils. The latter have lower specific gravity and refractive index and higher optical rotation. *d*-Pinene and *d*-camphene are the major components; together they constitute c. 80% of the oil. Other constituents present are: *β*-pinene, dipentene, *p*-cymene, *d*-linalool, 1-terpinen-4-ol, *dl*-*α*-terpineol, geraniol, safrole, eugenol, *iso*eugenol, an aldehyde with citral odour, myristicin (3-methoxy-4:5-methylenedioxy-1-allylbenzene), myristic acid and esters of myristic and

TABLE 1—PHYSICO-CHEMICAL CHARACTERISTICS OF NUTMEG OILS FROM DIFFERENT SOURCES

	East Indian[1]	West Indian[1]	Travancore[2]	I.P.[3]
Sp. gr.	0.880–0.913 (at 25°/25°)	0.859–0.865 (at 25°/25°)	0.8904 (at 30°)	0.882–0.910 (at 25°)
n	1.478–1.486 (at 20°)	1.4729–1.4746 (at 20°)	1.4775	1.470–1.486 (at 25°)
[α]	+7.9° to +22.16°	+25.8° to +38.5	..	+10° to +45°
Acid val.	..	..	0.12	..
Ester val. (after acetylation)	..	..	46.27	..
Solubility in 90% alcohol	1–2.5 vol. and more	2–3 vol. and more	..	3 vol.
Evaporation residue, %	0.3–2.1	0.2–0.8	..	3.0

[1] Guenther, V, 73–75; [2] Nair *et al.*, *Proc. Indian Sci. Congr.*, 1949, pt III, 102; [3] I.P., 433–34.

other fatty acids. Myristicin is toxic; when ingested in large amounts, it is liable to cause fatty degeneration of the liver (Guenther, V, 72–73, 75, 77–79; Heilbron & Bunbury, III, 543).

Nutmeg butter—Nutmeg contains 38–43% of ether extractable material which, in addition to glycerides, contains a volatile oil (6–13%), a small quantity of resin, and a substantial proportion of unsaponifiable material. Commercial nutmeg butter, a highly aromatic fat, is obtained from undersized, damaged or worm-eaten kernels which are unfit for sale as spice. The material is ground and cooked or steamed before pressing. A yield of 24–30% is reported. The fat may be obtained by solvent extraction but this process is not usually employed (Eckey, 407; Jamieson, 95; Thorpe, VIII, 259).

Nutmeg butter is a soft solid (m.p. 38–51°), yellow or yellowish red in colour, with the odour and taste of nutmeg. The analytical characteristics of the commercial product vary a great deal according to the method of preparation and the proportion of volatile oil and resin present. The recorded ranges of values are as follows: sp. gr.$^{15°}$, 0.945–0.960; $n_D^{40°}$, 1.4662–1.4704; iod. val., 33–65; acid val., 10–25; sap. val., 154–190; and unsapon. matter (containing myristicin), 8–18%. The fatty acid composition of purified fat extracted from Indian nutmegs was as follows (% of total fatty acids): lauric, 0.4; myristic, 71.8; palmitic, 14.3; stearic, 1.2; hexadecenoic, 4.8; oleic, 5.2; and linoleic, 1.5. The component glycerides were (in mol.%): fully saturated (trimyristin, 41.7; dimyristo-palmitin, 29.6), 71.3; disaturated mono-unsaturated, 20.5; and mono-saturated di-unsaturated, 8.2 (U.S.D., 1955, 874; Eckey, 407; Jamieson, 95; Pathak & Ojha, *J. Sci. Fd Agric.*, 1957, **8**, 537).

Nutmeg starch resembles legume starches in appearance and individual grains show, under the microscope, a well-developed cracked hilum. The grains are irregular in shape and vary in size from 5μ to 50μ; compound grains with up to ten components are common (Thorpe, VIII, 628).

Mace—Commercial mace consists of flattened lobed pieces, 2.5 cm. or more in length, somewhat less in breadth and *c.* 1 mm. thick. When soaked in water the lobes swell up and regain their original form. It is dull yellowish red in colour, translucent and brittle. In odour and taste it resembles nutmeg, but is softer and more delicate. Three types of mace are recognized in trade: (*i*) Banda mace, considered to be the finest; it has a bright orange colour and fine aroma; (*ii*) Java Estate mace is golden yellow, interspersed with brilliant crimson streaks; like Banda mace, it is free from insect infestation; and (*iii*) Siauw mace is of lighter colour than Banda mace and contains less volatile oil. Papua mace, often regarded as the fourth grade of East Indian mace, is derived from *M. argentea*; it contains comparatively little volatile oil and that too of an undesirable turpentine-like aroma; it is entirely unsuitable for distillation purposes. West Indian mace is comparatively inferior in quality. Bombay mace is derived from *M. malabarica*; it is dark red in colour and consists of narrow pieces, divided into numerous lobes twisted together at the apex. It is almost devoid of aroma, and is useless as a spice; it is often used as an adulterant of East Indian mace (Wallis, 229; Guenther, V, 61; Thorpe, VII, 343).

Composition—Analysis of mace gave the following values: moisture, 15.9; protein, 6.5; ether extr., 24.4; carbohydrates, 47.8; fibre, 3.8; and mineral matter, 1.6%; calcium, 0.18; and phosphorus, 0.10%;

iron, 12.6 mg./100 g. It contains a volatile oil (4–15%; av. 10%), amylodextrin (25%), reducing sugars, pectin and a resinous colouring matter. The chief constituents are the volatile oil (Oil of Mace), to which the flavour is mainly due, and amylodextrin. The oil closely resembles nutmeg oil in odour, flavour and composition and no distinction is made between them in trade. According to the specification of the Health Ministry, Government of India, mace spice shall contain: non-volatile ether extr., $\nless 20$ and $\ngtr 30\%$; crude fibre, $\ngtr 10\%$; total ash, $\ngtr 3\%$; and foreign organic matter and deteriorated material, $\ngtr 5\%$ (*Hlth Bull.*, No. 23, 1951, 44; Wehmer, I, 346; Guenther, V, 72).

Mace yields a fat similar to that from nutmeg but in a much smaller amount. A sample of Indian mace gave 26% of a red coloured fat (18–20% after removal of volatile oil) on extraction with carbon tetrachloride. It had the following characteristics: $d^{31°}$, 0.9884; $n^{35°}$, 1.4850; acid val., 3.4; sap. val., 108; iod. val., 153–57; R.M. val., 7.2; Polenske val., 0.72; acet. val., 65–67; and unsapon. matter, 35%. The characteristics of the refined oil, after removal of volatile and resinous matter, were as follows: $d^{28°}$, 0.9769; $n^{28°}$, 1.4835; sap. val., 161–62; and iod. val., 118–19 (Hill, 205; Pishawikar & Pishawikar, *Curr. Sci.*, 1953, **22,** 81).

The amylodextrin is present in mace in the form of granules, visible under the microscope (size, 5–7μ). They are compound and irregular in shape with a distinct hilum (Thorpe, VII, 433).

Leaves—The leaves of *M. fragrans* yield on water-distillation, 0.41–0.62% of a light brown volatile oil (sp. gr.$^{30°}$, 0.8642; n, 1.474; ester val., 8.44) with a pleasing spicy odour. Steam distillation of dried leaves (from East Indies) gave 1.56% of a colourless volatile oil (sp. gr.$_{4°}^{27.5°}$, 0.8772; $[\alpha]_D^{27°}$, 3.5°; $n^{26°}$, 1.4742) containing α-pinene (80%) and myristicin (10%) (Khan & Krishnaswamy, *Sci. & Cult.*, 1953–54, **19,** 186; Guenther, V, 79).

Bark—The bark of the tree yields 0.14% of a volatile oil with the following characteristics: $d^{26°}$, 0.871; $[\alpha]_D$, 12.2°; sap. val., 14; ester val. after acetylation, 37.5. A variety of kino is obtained from injuries made in the bark. A volatile oil is obtained also from flowers. The stem contains a tannin-mucilage complex (Gildemeister & Hoffmann, II, 413; Wehmer, I, 346; Burkill, II, 1529; *Chem. Abstr.*, 1939, **33,** 7846).

Fruit rind—Fresh pericarp from ripe fruit contains an acidic, astringent juice with an aromatic flavour. Analysis of the fruit rind gave the following values: moisture, 86.8; protein, 1.0; ether extr., 0.4; carbohydrates, 11.2; and mineral matter, 0.6%: calcium, 0.04; and phosphorus, 0.01%; iron, 2 mg.; and carotene (as vitamin A), 8 i.u./100 g. (Burkill, II, 1528, 1530; Chandler, 288; *Hlth Bull.*, No. 23, 1951, 44).

Uses—Both nutmeg and mace are used as condiment and in medicine; in eastern countries they are used more as a drug than as condiment. Nutmeg is stimulant, carminative, astringent and aphrodisiac; it is used in tonics and electuaries and forms a constituent of preparations prescribed for dysentery, stomach ache, flatulence, nausea, vomiting, malaria, rheumatism, sciatica and early stages of leprosy. Excessive doses have a narcotic effect; symptoms of delirium and epileptic convulsions appear after 1–6 hours. Mace is similarly used; it is also chewed for masking foul breath (Burkill, II, 1528–30; Kirt. & Basu, III, 2141; B.P.C., 1959, 502; Nayar, *J. Bombay nat. Hist. Soc.*, 1954–55, **52,** 515).

Oil of nutmeg or mace is employed for flavouring food products and liqueurs. It is used for scenting soaps, tobacco and dental creams, and also in perfumery. The oil is official in I.P. It is mildly counter-irritant and used in liniments and hair lotions. It has been recommended for the treatment of inflammations of bladder and urinary tract; the oil is somewhat toxic owing to the presence of myristicin and should be used with caution (Guenther, V, 79; Poucher, I, 302; Martindale, I, 631; Steinmetz, II, 285; Allen, IV, 86).

Nutmeg butter is used as a mild external stimulant in ointments, hair lotions and plasters, and forms a useful application in cases of rheumatism, paralysis and sprains. It is used in perfumes for imparting a spicy odour and in the manufacture of soaps and candles. Nutmeg butter is sometimes substituted by fats from other *Myristica* spp. (Thorpe, VIII, 259; Poucher, I, 302; Hill, 205).

Alcoholic extracts of nutmeg show anti-bacterial activity against *Micrococcus pyogenes* var. *aureus.* Aqueous decoctions are toxic to cockroaches. Myristicin present in the kernel may be employed as an additive to pyrethrum to enhance the toxicity of the latter to houseflies; myristicin by itself is inactive. The volatile oil from the leaf has weedicidal properties. It may also be used for scenting soaps, dentifrices, chewing gums and tobacco. It is not produced on a commercial scale (George *et al.*, *J. sci. industr. Res.*, 1947, **6B,** 42; Jacobson, 181; Khan & Krishnaswamy, loc. cit.; Guenther, V, 79).

TABLE 2—IMPORTS OF NUTMEG AND MACE NUTMEG

Year	Nutmeg Qty (tons)	Nutmeg Val. (Rs.)	Mace Qty (tons)	Mace Val. (Rs.)
1950-51 to 1954-55 (av.)	248.4	10,19,283	..	..
1956 (April-December)	209.5	12,79,720	..	..
1957	95.9	16,10,540	21.3	4,85,964
1958	56.5	12,07,259	6.9	1,75,041
1959	66.2	17,64,470	14.4	2,46,232
*1960-61	52.84	13,43,724	10.9	85,828

* Metric tons

The pericarp of the ripe fruit is locally used in pickles; it is used also in the preparation of jellies. Half-ripe fruits are candied in Malaya (Burkill, II, 1528; Chandler, 288).

Trade—Nutmeg trees are not grown to any large extent in India; considerable quantity of nutmeg and mace are imported from South-East Asian countries and consumed in India for culinary and medicinal purposes. Table 2 gives the quantity and value of imports in recent years.

M. malabarica Lam. FALSE NUTMEG, BOMBAY MACE TREE

D.E.P., V, 314; C.P., 791; Fl. Br. Ind., V, 103; King, *Ann. R. bot. Gdn Calcutta*, 1891, **3**, 288, Pl. 109.

TEL.—*Adavijajikaya*; TAM.—*Patthiri*; KAN.—*Kanagi*; MAL.—*Kattujattika, ponnampanu*.

A moderate-sized tree found at low elevations in the evergreen forests of western ghats from Konkan southwards. Bark greenish black, smooth; leaves oblong or elliptic-lanceolate, coriaceous; flowers in umbellate cymes, dioecious; fruits elongate oblong, (5-6.3 cm. × 2.5-3.2 cm.) densely rufous-tomentose; seed arillate, ovoid, slightly flattened on the side; testa shining, black, wrinkled: aril reddish yellow, irregularly lobed, laciniate, extending to apex of seed.

Ripe fruits of *M. malabarica* form the source of Bombay Nutmeg and Bombay Mace used as adulterants of the genuine products from *M. fragrans*. They are practically odourless and tasteless. Analysis of kernel gave the following values: moisture, 6.9; fat and resin, 40.76; protein, 6.5; carbohydrates, 42.18; fibre, 2.33; and ash, 1.33%; it contains 15-16% neutral fat. The characteristics of the crude fat are as follows: m.p. 31-31.5°; $n_D^{40°}$, 1.4580-1.4593; sap. val., 189-191; iod. val., 50-54; and R.M. val., 1.0-1.1. The components of the mixed fatty acids are: myristic, 39.2; palmitic, 13.3; other saturated, 2.4; oleic, 44.1; and linoleic, 1.0%. Analysis of a purified sample of fat (from Cochin) gave the following values: iod. val., 22; Hehner val., 94.75; and unsapon. matter, 2%; the fatty acid components were: myristic, 69; palmitic, 10; and oleic, 21%. The glyceride composition of the fat was as follows: tri-saturated, 57; di-saturated mono-unsaturated, 33; mono-saturated di-unsaturated, 8; and tri-unsaturated, 2% mol. (Hooper, *Agric. Ledger*, 1907, 17; Eckey, 408, 412; Kartha, *J. sci. industr. Res.*, 1954, **13A**, 72).

The major part of the resinous matter present in the seed kernel is phenolic in nature and may be employed as an antioxidant for the protection of oils and fats against rancidity. The resinous matter along with the fat is extracted by ethyl acetate (total extractives, 41-43%) and nearly half of the total extractive consists of active resin soluble in oil; a portion of it has been obtained in crystalline form, m.p. 120-22°. The oil soluble resin imparts but little colour to *Vanaspati*, ghee or lard and affords effective protection against rancidity in a concentration of 0.008%. Comparative tests have shown that the resin is at least as effective as Butylated Hydroxy

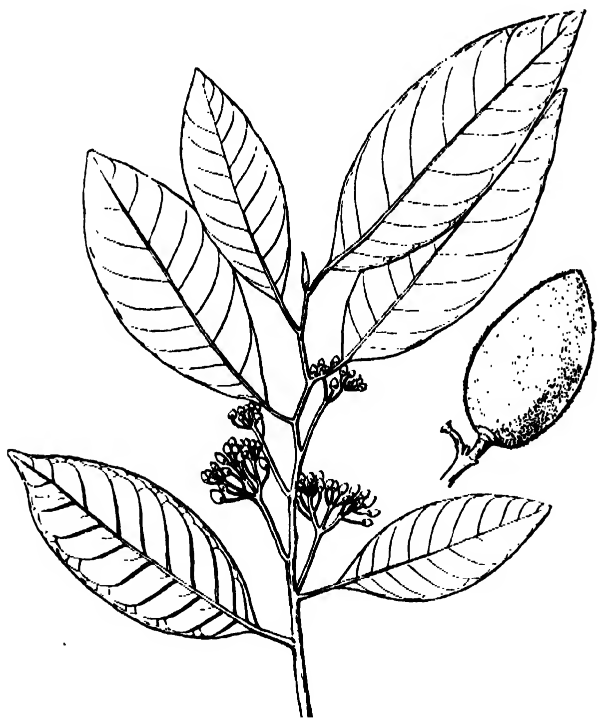


FIG. 185. MYRISTICA MALABARICA—FLOWERING BRANCH AND FRUIT

Toluene (BHT), one of the best edible fat antioxidants in use (Duggal & Kartha, *Indian J. agric. Sci.*, 1956, **26**, 391).

Analysis of mace from *M. malabarica* gave the following values: moisture, 4.07; fat and resin, 63.26; protein, 7.31; carbohydrates, 20.80; fibre, 3.06; and ash, 1.50%. Fat and resin are the major constituents; amylodextrin, glucose, starch, a volatile oil (0–0.67%) and colouring matter are present. The fat is similar to that from the kernel. The resin possesses antioxidant properties; only a small part of it is soluble in oil and weight for weight, the resin is less active than that from the kernel (Hooper, loc. cit.; Wehmer, I, 344; Duggal & Kartha, loc. cit.).

The seeds of *M. malabarica* are used in external application for indolent ulcers. The crude fat (Pundi Oil) which separates out as a surface layer when crushed kernel is boiled with water, is used as an embrocation in rheumatism, sores and pain; it is used also as an illuminant. The bark yields a kino (Wehmer, I, 345).

The wood is light (wt., 32–39 lb./cu. ft.) reddish brown, moderately hard and not durable. It is locally used in building construction. It is used for tea boxes in Ceylon and considered suitable for light furniture, match boxes and splints (Krishnamurti Naidu, 90–91; Gamble, 555; Rama Rao, 339).

M. magnifica Bedd. (Tam.—*Chura panu*; Kan.—*Ramanadike*; Mal.—*Kotthapanu, churapayin*) is a tall, evergreen tree, up to 36 m. in height and 0.9 m. diam., growing gregariously in western ghats from Kanara southwards and in parts of Tirunelveli. The wood is light (wt., 30 lb./cu. ft.) and may be used for match boxes and splints. In South Kanara, the red arils from seeds are employed for dyeing purposes. The seeds yield an oil used for burning and for making candles (Krishnamurti Naidu, 90; Rama Rao, 339).

Myristica spp. — *see* **Gymnacranthera, Horsfieldia, Knema**

Myrobalan — *see* **Emblica, Terminalia**

MYROXYLON Linn. f. (*Leguminosae*)

A small genus of evergreen trees native of tropical America. Two species, *M. balsamum* and *M. pereirae*, which yield fragrant gum resins used in medicinal preparations and perfumery, have been introduced into India and grown in gardens for ornament.

M. balsamum Harms syn. *M. toluiferum* H.B. & K.
Tolu Balsam Tree

Chittenden, III, 1342.

A tall tree, 12–30 m. high, with a spreading crown. Leaves imparipinnate: leaflets oblong; flowers yellowish, in small axillary racemes.

M. balsamum, the source of Tolu Balsam, is indigenous to Venezuela, Colombia and Peru. It is grown in Lal Bagh Botanic Garden (Bangalore) and Kallar (Nilgiris); some areas in S. India and eastern Himalayas at altitudes of 450–900 m. are considered suitable for its cultivation. It may be grown as a shade tree for cultivated crops (Krumbiegel, 34; Krishnamurthi, 144; Nayar & Chopra, 38; Macmillan, 212).

The balsam forms in trunk tissues as a result of injuries. Deep V-shaped incisions are made in the trunk with machetes and the balsam which exudes is collected in calabash cups inserted in excavations immediately below the cuts. The collected exudate is emptied into bags of raw hide and thence transferred to cylindrical tins for export. Collection of the balsam continues all the year round, except for the period of heavy rains. Commercial preparations are occasionally adulterated with rosin, but the usual sophistication is the natural balsam from which the aromatic substances have been abstracted (Guenther, V, 221; Youngken, 437–38; U.S.D., 1955, 1439–40; Allen, IV, 325).

Tolu balsam is a soft, brown or yellowish brown semi-solid mass with a pleasant, aromatic and lasting odour reminiscent of vanilla and an aromatic taste. It becomes hard and brittle on ageing. Warmed and pressed between pieces of glass and examined with a lens, it exhibits crystals of cinnamic acid. The balsam has the following constants (on the basis of dry alcohol-soluble matter): acid val., 97–160; ester val., 47–95; sap. val., 170–224; balsamic acids, 35–50%; it is soluble in 90% alcohol, ether and chloroform. It contains a mixture of resinous substances (75–80%), benzyl benzoate, benzyl cinnamate, a volatile oil and traces of vanillin. The resins consist of cinnamic and benzoic acid esters of a complex alcohol, tolu-resinotannol ($C_{17}H_{18}O_5$). The volatile oil (Oil of Tolu Balsam) is obtained in a yield of 1.5–7.0% by steam-distillation of the balsam. It has a pleasant, lasting odour, somewhat suggestive of hyacinth. It contains benzyl benzoate, benzyl cinnamate, phellandrene (?) and farnesol (I.P., 75; Guenther, V, 221–23; Thorpe, I, 617).

A volatile oil distilled directly from the wood contained *l*-cadinol as the major constituent together with *d*-cadinene, farnesol and traces of nerolidol (Guenther, V, 224).

Tolu balsam is official in the Indian pharmacopoeia. It is antiseptic, stimulant and expectorant and used as an ingredient of cough mixtures. It is also used as an inhalent in cases of obstinate catarrh. Official preparations of the balsam are Tolu Balsam Syrup and Tolu Balsam Tincture. Ethanol extracts of the balsam show anti-bacterial activity against *Mycobacterium tuberculosis* (U.S.D., 1955, 1440–41; Trease, 391; Guenther, V, 224; Nickell, *Econ. Bot.*, 1959, **13**, 281).

The oil of Tolu balsam is used in perfumes, cosmetics and soaps. It blends well with certain floral and oriental types of compositions. The resinoid, obtained from the balsam by repeated extraction with alcohol has good fixative properties; it imparts warm tonalities to perfume compounds (Guenther, V, 224–25).

The quantities of Tolu balsam imported into India during 1957, 1958, 1959 and 1960–61 were respectively 136 cwt. (value, Rs. 184,582), 100 cwt. (value, Rs. 133,734), 153 cwt. (value, Rs. 189,531) and 276 cwt. (value, Rs. 282,795). Tincture of Tolu Balsam is also imported: the quantities imported during 1957, 1958, 1959 and 1960–61 were respectively valued at Rs. 35,231, Rs. 5,084, Rs. 1,138 and Rs. 15,525.

The wood of *M. balsamum* (sp. gr., 0.90–1.10; wt., 56–58 lb./cu. ft.) is hard, strong and fragrant; it varies in colour from yellow orange to purplish rose. It is moderately durable, difficult to work, but finishes to a smooth surface with high natural polish. It is used for decorative cabinet work (Record & Hess, 299; Howard, 431).

M. pereirae Klotzsch PERU BALSAM TREE
Chittenden, III, 1342.

A large spreading tree, 9–15 m. or more in height, indigenous to tropical America. Bark smooth, grey; leaves imparipinnate: leaflets oblong; flowers small, whitish, in axillary racemes; fruit a yellowish brown legume, narrowed towards the stalk end, one-seeded.

M. pereirae, the source of Peru Balsam, has been grown in the Lal Bagh Botanic Garden, Bangalore; a stray specimen is found growing in Calcutta. Its cultivation may be tried in S. India near about Bangalore (Krumbiegel, 18; Benthall, 141; Nayar & Chopra, 38).

Peru balsam is extracted from trees, 25 years and more in age. Commercial balsam is sometimes found adulterated with colophony or gurjun balsam; the more usual adulterant is the so-called artificial balsam of Peru based on benzyl benzoate (Guenther, V, 213; Allen, IV, 327, 329).

Peru balsam is a viscous, dark brown, transparent liquid which does not harden on exposure to air. It has a bitter, acrid taste and a pleasant lasting odour somewhat recalling that of vanilla. It contains 25–30% resin and 60–65% of a volatile oil to which its therapeutic virtues are due. The oil known in the trade as Oil of Peru Balsam or Cinnamein is obtained from the balsam by extraction with petroleum ether or benzene. It is a reddish brown, slightly viscous liquid with a sweet balsamic and lasting odour. It contains benzyl benzoate and benzyl cinnamate as the principal constituents; *d*-nerolidol, farnesol, cinnamyl cinnamate and vanillin are present (Guenther, V, 215–18; U.S.D., 1955, 1023–24).

Peru balsam is used externally in the form of an ointment or tincture as a parasiticide in scabies, ringworm, pediculosis, sluggish granulations, ulcerated surfaces, bed sores and chilblains. It is used as an antiseptic and stimulating dressing for wounds and indolent ulcers. Occasionally it causes dermatitis. It can be used internally, in the form of an emulsion, as a stimulating expectorant. The balsam enters into the preparation of certain rectal suppositories used for symptomatic relief of haemorrhoids and other anal conditions. Ethanol extracts of the balsam show anti-bacterial activity against *Mycobacterium tuberculosis*. Peru balsam is used in veterinary practice as a dressing for wounds (U.S.D., 1955, 1024; Youngken, 437; B.P.C., 1959, 546; Trease, 393; Nickell, *Econ. Bot.*, 1959, **13**, 281; Merck Index, 114).

The balsam and the oil are used in perfumes, soaps and cosmetics. The balsam blends well with perfume compositions and serves as a fixative imparting warmth to perfumes. It is used also as a substitute for vanilla (Guenther, V, 220; Poucher, I, 332; Hill, 168–69).

The quantities of Peru balsam imported into India during 1957, 1958, 1959 and 1960–61 were respectively 6 cwt. (value, Rs. 5,915), 1 cwt. (value, Rs. 1,281), 2 cwt. (value, Rs. 2,557) and 8 cwt. (value, Rs. 7,554).

The wood of *M. pereirae*, exhausted of balsam, yields an essential oil which is rich in nerolidol (68–70%); the latter is valued for imparting smooth tonalities to perfume compositions. Fruits and leaves

also contain essential oil. The wood is used for furniture, interior trim and railway crossties (Naves, *Perfum. essent. Oil Rec.*, 1948, **39,** 280; Guenther, V, 219; Record & Hess, 298).

Myrrh — *see* **Commiphora**

MYRSINE Linn. (*Myrsinaceae*)

A fairly large genus of shrubs and small trees distributed in Asia and Africa. Five species occur in India.

M. africana Linn.

D.E.P., V, 315; Fl. Br. Ind., III, 511; Collett, 304, Fig. 94.

PUNJAB—*Bebrang, kakhum, shamshad*; KASHMIR—*Gugil*; KUMAON—*Ghani*; GARHWAL—*Rikhdalmi*.

An erect shrub or small tree, 0.6–1.2 m. high, found in the outer Himalayas from Kashmir to Nepal and Khasi hills at altitudes of 300–2,700 m. Leaves lanceolate or obovate, sharply toothed; flowers minute, white, in axillary clusters; fruit small, globose, fleshy, dark purple, containing a single seed.

M. africana is considered suitable for hedges; it is readily propagated by seeds or cuttings. The fruit of the plant is edible. It has anthelmintic properties and is particularly effective for the expulsion of tape worms; it is used as a substitute for embelia (from *Embelia ribes*). The active principle is embelin (2-undecyl-3:6-dihydroxy benzoquinone, m.p. 142–43°) which is present in the dried fruit to the extent of 3%. The fruit contains also quercitol (1%). Seeds also contain embelin. The fruit is used as a laxative in dropsy and colic; an ointment prepared from it is considered effective against ringworm and other skin affections. The plant yields a gum (Kirt. & Basu, II, 1477; Chopra, 1958, 367, 679; Krishna & Varma, *J. Indian chem. Soc.*, 1936, **13,** 115; *Indian For. Bull., N.S.*, No. 102, 1941; Thomson, R. H., 21–23).

M. semiserrata Wall.

D.E.P., V, 316; Fl. Br. Ind., III, 511.

PUNJAB—*Parwana, gogsa*; KUMAON—*Chupra*; GARHWAL—*Bains, gaunta*; NEPAL—*Phalame, jhingni*; LEPCHA—*Singgun*.

A shrub or small tree, usually 0.9–1.8 m. high occasionally up to 4.5 m., found in the outer Himalayas between Beas and Bhutan, in North Bengal and in Khasi, Jaintia, Aka and Lushai hills at altitudes of 900–2,700 m. Leaves lanceolate, sharply toothed towards tip, rarely entire; flowers pinkish, in dense axillary fascicles; fruit globose, bluish or pinkish purple when ripe.

M. semiserrata is regarded as a medium fodder tree in U.P. The seeds of the plant contain embelin (0.4%), quercitol (0.8%) and fatty matter (1.8%). The wood (wt., 51 lb./cu.ft.) is hard, heavy, red or chocolate-coloured and handsome; it is apt to split. It is suitable for axe handles and carpentry (Laurie, *Indian For. Leafl.*, No. 82, 1945, 10; Krishna & Varma, *Indian For. Bull., N.S.*, No. 102, 1941; Gamble, 439; Rodger, 16).

M. capitellata Wall. = *Rapanea capitellata* (Wall.) Mez (NEPAL—*Phalamkath*; ASSAM—*Kavhidria*; KHASI—*Dieng-ching*) is a shrub or small tree found in Nepal, Bhutan, North Bengal, Assam and Khasi, Jaintia and Aka hills. It is a very variable species and includes 2 or 3 varieties; var. *lanceolata* C. B. Clarke (= *Rapanea wightiana* Mez) is found also in the hills of S. India at altitudes above 1,800 m. The fruit is edible. Seeds contain embelin (1.6%). The wood of var. *lanceolata* is moderately hard and durable (Krishna & Varma, *Indian For. Bull., N.S.*, No. 102, 1941).

Myrtan — *see* **Eucalyptus**

Myrtle, Box — *see* **Myrica**

Myrtle, Common — *see* **Myrtus**

Myrtle, Crape — *see* **Lagerstroemia**

MYRTUS Linn. (*Myrtaceae*)

A large genus of shrubs, rarely trees, distributed in South America, South Europe, West Asia and Australia. One species has been introduced into India and grown in gardens throughout the country.

M. communis Linn. COMMON MYRTLE

D.E.P., V, 316; Fl. Br. Ind., II, 462; Kirt. & Basu, Pl. 417B.

HINDI—*Vilayati mehndi, murad*; BENG.—*Sutrasowa*; MAR.—*Malati*; GUJ.—*Makali-na-patran*.

An evergreen shrub, 1.0–3.0 m. or more in height, often grown for its attractive foliage, flowers and berries. Leaves opposite, ovate to lanceolate, aromatic; flowers white, fragrant, axillary; berries ellipsoid, blue black with hard, kidney-shaped, white seeds.

M. communis includes a large number of cultivated types differing in the size and shape of leaves and in stature; a variegated form is also known. It is easily propagated by seeds, cuttings or layerings. It flowers

in March–April and bears fruits in the cold season (Bailey, 1947, II, 2096; Gopalaswamiengar, 281; Firminger, 526).

The aromatic leaves of the plant are highly esteemed as a flavouring for culinary purposes. Leaves and flowers are used in garlands and bouquets and the volatile oil extracted from them is used in perfumery. Various parts of the plant are regarded as medicinal. Leaves are astringent and reported to be useful in cerebral affections, especially epilepsy, pulmonary disorders, dyspepsia and diseases of stomach and liver. A decoction of leaves is used as a mouth wash in apthae; leaves are also used for eczema, wounds and ulcers. Berries are carminative and given in diarrhoea, dysentery, haemorrhage, internal ulcerations and rheumatism. Aqueous and ethanol extracts of roots, leaves and stem are active against Gram-positive and Gram-negative bacteria and *Mycobacterium tuberculosis*. A thermo-labile active principle, highly toxic to *Micrococcus pyogenes* var. *aureus* and resembling streptomycin in its action on *Mycobacterium tuberculosis*, has been reported [Krishna & Badhwar, *J. sci. industr. Res.*, 1950, **9A**(3), suppl., 233; Gopalaswamiengar, 281; Kirt. & Basu, II, 1041; Wren, 247; Nadkarni, I, 838; Nickell, *Econ. Bot.*, 1959, **13**, 281; *Hort. Abstr.*, 1960, **30**, 123].

The leaves and flowers on steam-distillation yield an essential oil, known as Myrtle Oil. The yield and quality of oil depend upon the region of production, the season of harvest and the length of distillation. Fresh leaves and flowering tops, without woody branches, yield the best oil. Myrtle oil is yellow or greenish yellow in colour with a characteristic refreshing odour. The physico-chemical properties of the oil (from Corsica) are as follows: sp. gr.$^{15°}$, 0.883–0.887; $[\alpha]_D$, +22° to +27°; $n^{20°}$, 1.464–1.470; acid val., up to 1.7; ester val., 13–25; ester val. after acetylation, 30–38; sol. in 1 vol. of 90% alcohol but not sol. in 10 vol. of 80% alcohol. The oil contains α-pinene, camphene (?), dipentene, cineole, myrtenol ($C_{10}H_{16}O$, present mostly as acetic ester), geraniol, nerol and aldehydes (Krishna & Badhwar, loc. cit.; Guenther, IV, 363–69).

Myrtle oil is used with advantage, in place of dried leaves, as a flavouring for culinary purposes. It is used for scenting soaps and toilet waters, especially Eaux de Cologne, to which it imparts an agreeable spicy note. It is used as a disinfectant, antiseptic and rubefacient, and in affections of the respiratory tract and bladder; it is recommended as a local application in rheumatic affections (Guenther, IV, 369; Poucher, I, 294; Kirt. & Basu, II, 1041; Nadkarni, I, 838).

The berries contain an essential oil, citric acid, malic acid, resin and tannin. They are used for flavouring wines and foods. The seeds yield 12–15% of a fatty oil consisting of glycerides of oleic, linoleic, myristic and palmitic acids. The wood of *M. communis* has an attractive mottled appearance; it may be used in turnery (Wehmer, II, 825; Neal, 555; Krishna & Badhwar, loc. cit.).

MYXOPYRUM Blume (*Oleaceae*)

A small genus of scandent shrubs distributed from India through Burma and Malaya up to New Guinea and Bismarck Archipelago. Two species occur in India.

M. serratulum A. W. Hill syn. *M. smilacifolium* C. B. Clarke (Fl. Br. Ind.) in part, non Blume

Fl. Br. Ind., III, 618; Hill, *Kew Bull.*, 1910, 41.

MAL.–*Chathuravalli, chathuramulla.*

A large scandent shrub found in western ghats in Wynaad and Travancore at altitudes of 600–900 m. Leaves obovate-elliptic or elliptic, serrulate; flowers yellow, in axillary or terminal panicles; fruit obovoid with one or two seeds.

The leaves of the plant are powdered and taken with ghee as a remedy for asthma, cough, rheumatism, nervous complaints and consumption. Leaves ground and boiled in oil are applied in fever, headache, ear diseases and back aches (Rama Rao, 249).

INDEX

(Names in Indian Languages, Regional and Trade Names and Common English Names)

V

M

N

T

U

V

W

Y

Z

338.03/COU
45907